Outcomes and Impacts of Blow-out Fractures of The Orbit

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A thesis submitted for the degree of Doctor of Philosophy at Newcastle University

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Acknowledgment

I cannot thank enough Dr. Ian Corbett for his continuous support. I have been privileged by the way he helped me to handle the research question in the best possible way along the study journey. I am deeply grateful to his kind guidance.

I would like to express my deep gratitude to Dr. Justin Durham, who provided me with the best of his knowledge and experience in the field of quality life and qualitative research. He was keen to guide me through every step in these fields of research to ensure the highest possible standards.

I would like to thank Professor Mark Greenwood for being there whenever I wanted his support, guidance and invaluable feedback. I would like, also, to express my highest regards to Dr. Nick Strong and Professor Jimmy Steele for their support, and useful comments on this work.

I would like to express my gratitude to Kat Taylor who gave me from her time and effort to have the knowledge about the necessary orthoptic tests. My thanks to all the staff in Oral and Maxillofacial department; the consultants, the senior house officers, the receptionists and nursing staff who kept me informed about all new patients and updated me with their treatment courses. I would like to thank all the patients who participated in this study and provided me with their insight and experience, and I wish them the best in their future life.

I would like to express my deep gratitude to my family, friends and colleagues who supported me from the beginning of this journey in Baghdad and along the way through in Newcastle. I will be always thankful for their unlimited support and prayers.

Finally, I would like to thank my beloved wife Areej for her dedication, commitment, all the support and help I wished for. I hope that she benefited from this long journey as much I hope for myself.

Abstract

A blow-out fracture of the orbit is defined as one with orbital wall and or floor fracture without orbital rim involvement. The management of this injury and its timing continue to be a matter of some debate. One of the main reasons for this debate is the lack of unifying objective, quantitative, clinical measures of diplopia severity that encompass both the clinical and patient perspectives.

This thesis consists of two distinct studies: one study examines the factors associated with outcome of blow-out fractures, whilst the other examines the patient perspective and experience of this type of fracture. The aim of this thesis is to study the impacts and determine the factors that influence management outcomes with regard to diplopia. A combination of retrospective data and qualitative data was used to help achieve this aim.

The retrospective study demonstrated binocular single vision assessment to be a valuable tool in assessing management outcome. In addition, the data demonstrate it has a significant prognostic value in blow-out fractures of the orbit: lower pre-operative diplopia scores, the more chance of improvement in diplopia scores after surgery. Lower pre-operative diplopia scores were associated with a longer follow up time and a greater number of follow up visits required.

Demographic factors, surgical timing, type of surgical approach and surgical implant material were shown to have no significant influence on diplopia. Orbital fat herniation in the absence of orbital muscle involvement, as determined by CT scan interpretation, appears to have no significant influence on diplopia when compared to fractures where no tissue herniation was observed on diplopia scores in blow-out fractures.

The impact of blow-out fractures from the patient's perspective was reflected through distress and frustration which negatively influence patients' daily activities, including their employment. This distress and frustration was reported to centre around the individual's fear of losing their vision. This misconception appears to be due to potentially ineffective patient-clinician communication.

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Introduction

Trauma to the orbit can result in soft tissue and or hard tissue injuries. This thesis concentrates on isolated fractures of the orbital walls/floor or 'blow-out fractures'. The sequelae of such injuries include diplopia, enophthalmos and infraorbital paraesthesia.

The term orbital 'blow-out' fracture, relating to a fracture of the orbital wall/floor without orbital rim involvement, was coined by (Converse and Smith, 1957). Since its recognition as a unique entity, much debate has taken place on the mechanisms of injury, predictive value of investigations and management regimens.

Development of management protocols for orbital blow-out fractures has been hampered by lack of objective, quantitative clinical measures of severity of diplopia. As a result, lack of standardised measures of outcome makes direct comparison of management protocols difficult.

Current orthoptic investigations in the assessment of diplopia include Hess charts, binocular single vision, uniocular fields of fixation and cervical range of movement tests. The binocular single vision (BSV) test is of particular interest, its use being reported recently by several authors (Kim and Woo, 1999; Stocker *et al.*, 2005; Banks, 2007). However, this has not been put into context in determining the influence of various demographic, radiological and surgical factors on diplopia associated with this type of injury.

Current opinion in the management of blow-out fractures is toward early surgical intervention (Ogata et al 2004, Jaquery et al 2007, and Kuttenberger et al 2008) based on the subjective judgment of disability caused by diplopia. However, there is some evidence in the recent literature suggests otherwise (Jin *et al.*, 2007; Shin *et al.*, 2011). Furthermore, there is a group of patients in which there is a slow but steady resolution of diplopia without intervention (Putterman 1991). This leads to a management dilemma over whether to surgically intervene earlier or whether to manage conservatively initially.

Patients' experiences of this type of facial trauma have not been thoroughly investigated. Blow-out fractures with diplopia-related disability and or aesthetic concerns may exert both psychological and social influences on patient's lives. Knowledge of such influences could help physicians to comprehensively address trauma related problems and help patients to cope with negative outcomes.

This research project tries to address orbital blow-out fractures management problems through studying the factors that influence its impact and outcome. This will be achieved employing quantitative and qualitative approaches. The quantitative study bases on 10 year retrospective data. Whereas the qualitative study bases on data extracted from semi-structured interviews with blow–out fractures' patients. The retrospective study tries to determine the influence of various factors, BSV score in particular, on diplopia outcome. The value of BSV influence may help to consider BSV as a unifying objective measure for diplopia in blow-out fracture of the orbit. Qualitative study, on the other hand, will provide an insight to patient's experience, by studying the psychological and social impact caused by blow-out fractures of the orbit on patient's life.

Chapter 1 Surgical anatomy of the orbit

1.1 The bony orbit

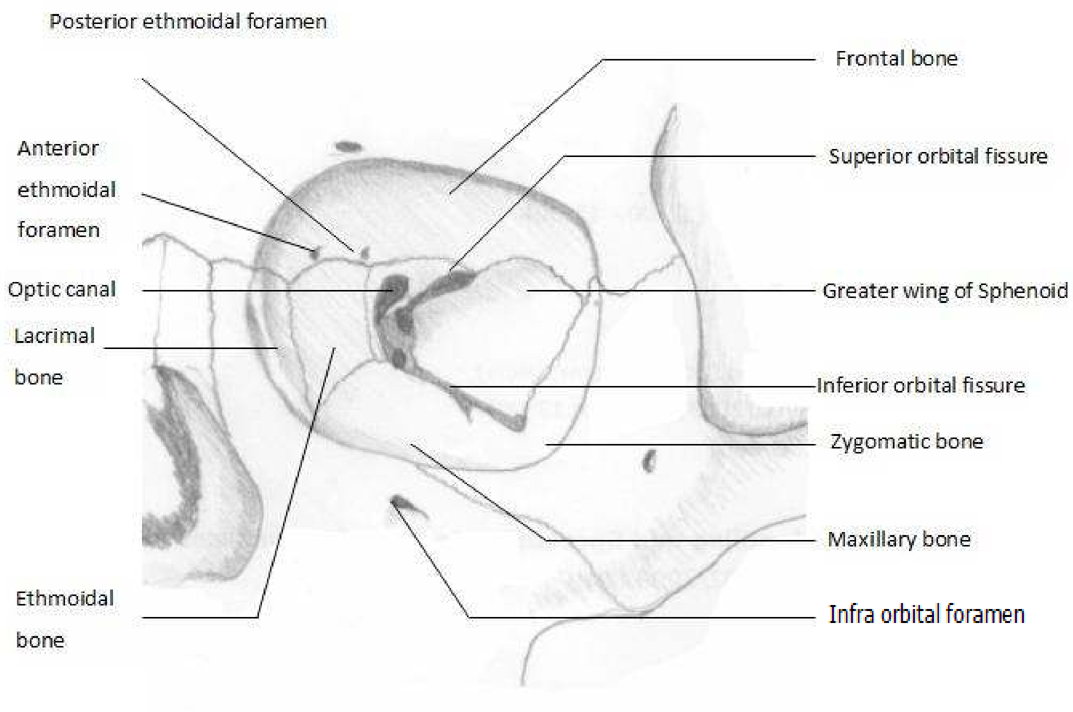


Figure 1-1: the bony orbit (adapted from Brady et al 2001).

The bony orbit is a roughly quadrilateral, pyramidal cavity with its base directed forwards and lateral. It is comprised of 7 bones: maxilla, palatine, frontal, zygomatic, sphenoid, ethmoid and lacrimal bones (Figure 1-1).

The lateral orbital wall consists of zygomatic bone and the greater wing of the sphenoid. It inclined at 45 degree to the anteroposterior axis of the skull. The roof of the orbit is thin but it is reinforced laterally by the greater wing of sphenoid and the superior orbital rim. The medial wall is formed basically from the thin orbital plate of the ethmoid bone and is aligned parallel to the anteroposterior axis of the skull. Being adjacent to the ethmoidal air cells, and more anteriorly to the nasal cavity, the medial wall is fragile and thus it is frequently grossly disrupted in nasoethmoidal fractures with lateral displacement, giving the classical sign of hypertelorism.

At the level of the optic foramen, close to the junction of the medial wall and roof, there are two to three foramina through which pass branches of the ethmoidal artery. These foramina are important landmarks during the dissection of this region.

The floor of the orbit is the prevalent site involved with pure blow-out fractures of the orbit. It slopes upward and medially until it becomes horizontal as it approaches the anterior margin of the inferior orbital fissure. The floor then curves downwards steeply into the infratemporal fossa to form the posterior wall of the maxillary antrum. Reconstruction of the orbital floor which involves this area therefore requires special attention to re-establishing this sigmoid shape.

The orbital floor is very thin and it is further weakened by the presence of the infraorbital groove and canal. Most of the blow-out fractures of the orbital floor occur immediately medial to the infraorbital groove and canal, and therefore frequently involve the infraorbital nerves and vessels, either by compression or contusion. `

1.2 Soft tissues of the orbit

The eyelids are covered by a thin skin which overlies a lax areolar tissue. It has a profuse blood supply. Opening of the eye is achieved by levator palpebrae superioris muscle, which is innervated by the oculomotor nerve. Eye closure is carried out by the orbicularis oculi, supplied by the facial nerve.

The orbital septum (Figure1-2) consists of a fibrous diaphragm extending from the periphery of the orbit to the tarsal plates. This septum prevents the escape of blood or pus outside the orbit if present with the orbit. Collections within this compartment may therefore lead to an increase in the retrobulbar pressure, which may cause vascular occlusion and hence interfere with the circulation to the retina and consequently affect sight. Retrobulbar collections are, therefore considered a surgical emergency. Because the orbital septum is incomplete in its medial and inferior aspect, a nasoethmoidal fracture may result in peri-orbital emphysema of the lids with subsequent air collection anterior to the tarsal plates, often associated with the nose blowing. The emphysema usually spontaneously resolves, although may need decompression if significant. The tarsal plates form the skeleton of the eyelids, are semilunar in shape, and are formed by dense connective tissue. The canthal (palpebral) ligaments are two almost Y shaped fibrous extentions of the tarsal plates to the lateral and medial walls.

The conjunctiva is a highly vascular structure, except in the area which covers the cornea which is devoid of blood vessels. Subconjunctival heamorrhage hence ceases at the corneal margin. It has a firm attachment in the palpebral portion but loose attachment where it covers the sclera.

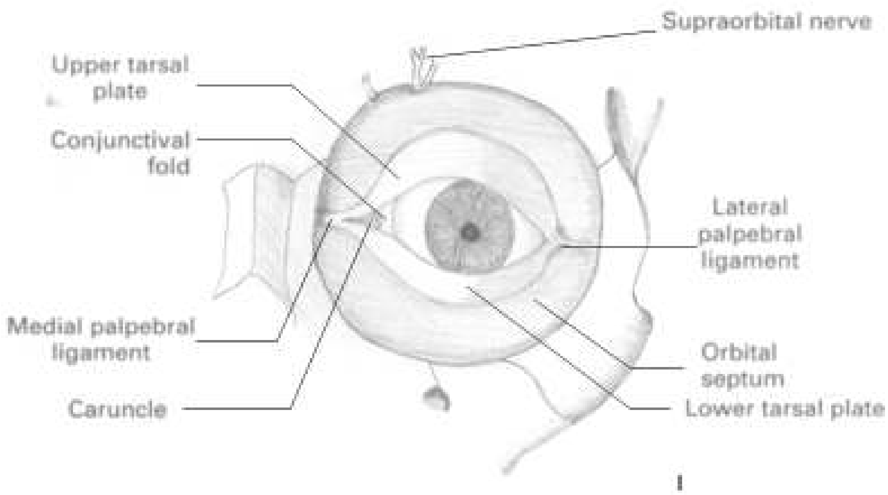
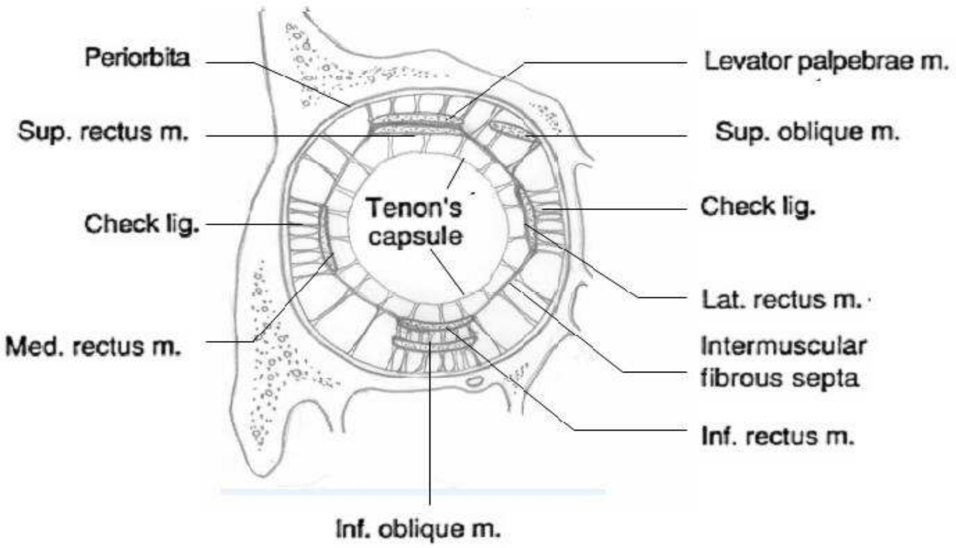


Figure1-2: Left orbital septum (adapted from Last 1999).

The lacrimal apparatus is involved in the production of tears and the removal of excess tears. The lacrimal apparatus consists of the lacrimal gland, lacrimal canaliculi, lacrimal sac and the nasolacrimal duct. Under normal conditions the lacrimal gland secretes just enough tears to replace those lost by evaporation. The nerve supply comes from superior nucleus via the greater petrosal nerve. The postganglionic fibers run with the zygomatic branch of the maxillary nerve, which anastomoses with the lacrimal nerve.

There is a layer of periorbital fat which acts as a cushion upon which the extra-ocular muscles of the eye can move and rotate the eyeball within the capsule of Tenon, which is a thin membrane which envelops the eyeball from the optic nerve to the limbus. There are a large number of fibrous septa within the periorbital fat, which may become entrapped with the fat in orbital blowout fractures lead to interference with the free movement of the extraocular muscles. Periorbital fat fills both intraconal and extraconal spaces.

Koornneef (1982) in his anatomic and histological study of the orbit, found a fine ligament system, interconnecting the orbital soft tissue with the bony orbit (Figur 1-3). The presence of such a ligament system could play an important role in extraocular muscle motility defects, without the need for actual muscle entrapment.



Figur 1-3: Schematic representation of a coronal section through mid-orbit demonstrates complex system of ligaments and septa which support the globe and extraocular muscles (adapted from Iliff, 1991).

1.2.1 Muscles of the orbit:

The eyeball is moved by extrinsic or extra-ocular muscles (Figure 1-4), consisting of four rectus (superior, inferior, medial and lateral) and two oblique (superior and inferior) muscles. The orbit also contains the levator palpebrae superioris for moving the upper lid.

The extraocular muscles, posteriorly, travel adjacent to the orbital walls, and are readily identifiable on CT scans. Here they are vulnerable to the effects of fracture and to the trauma of surgical dissection.

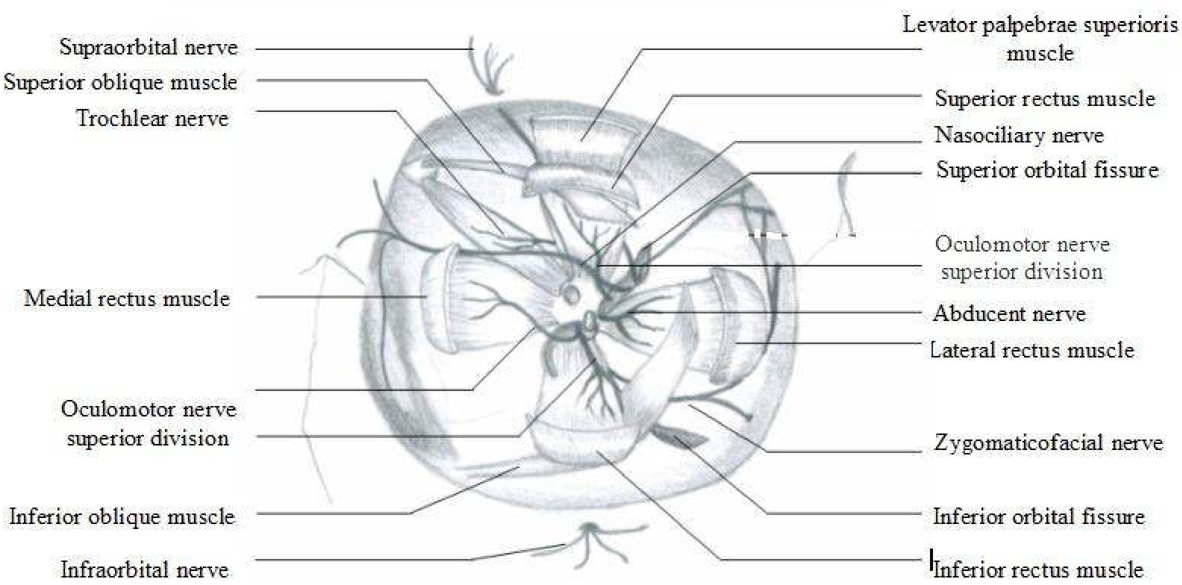


Figure 1-4: Orbital muscles and nerves (left side) (adapted from Brady et al 2001)

The four rectus muscles originate from the common tendinous ring which surrounds the superior orbital fissure and the optic canal. As these muscles pass forwards from the apex of the orbit they broaden out, to form a cone of muscles around the eye. They all pierce the fascial sheath of the eyeball and are inserted into the sclera anterior to the coronal equator of the eye.

A mock chemical formula is often used an aid to memorizing the cranial nerve supplies of the eye muscles: LR6SO4, indicating that the lateral rectus is supplied by the sixth (abducent) nerve and the superior oblique by the fourth nerve (trochlear). All other muscles (superior, medial and inferior rectus and inferior oblique) are supplied by the third nerve (oculomotor).

1.2.2 Nerves of the orbit

The optic nerve is essentially an extension of the brain and is covered by dura, arachnoid and pia mater. In contrast to the immobile intracanalicular portion of the nerve, the orbital portion enjoys considerable mobility which decreases the likelihood of its injury in orbital trauma. The infraorbital nerve enters the orbit accompanied by the zygomatic nerve and infraorbital artery. The infraorbital nerve and artery occupy a groove in the posterior part of the orbital floor. Both enter the infraorbital canal and continue to the face, supplying nerves to the maxillary sinus and the anterior teeth *en route*.

The zygomatic nerve passes along the lateral wall and divides into its zygomaticotemporal and zygomaticofacial branches. The former gives secretomotor fibers to the lacrimal nerve for the lacrimal gland

The oculomotor and the abducent nerves are situated inside the tendinous ring, and are therefore better protected than the trochlear nerve, which is more vulnerable along its course as it crosses above the origin of the levator and the muscle cone running along the upper part of the medial wall. The nerve to the inferior oblique muscle leaves the protection of the muscles between the inferior rectus and the lateral rectus and is at risk because of its proximity to the floor of the orbit.

1.2.3 Vessels of the orbit

The ophthalmic artery, a branch of the internal carotid artery, enters the orbit through the optic canal within the dural sheath of the optic nerve. It gives off several branches that accompany the branches of nasociliary, frontal and lacrimal nerves. It supplies the ethmodial air cells, the external nose, the eyelids and forehead. The blood supply to retina is derived from the central retinal artery, a branch of the ophthalmic artery.

1.2.4 The globe of the eye

The eye contains the light sensitive retina and it is provided with a lens system, the cornea, lens and refractive media, for focusing images and with means of controlling the light admitted, the iris diaphragm. The inside of the globe is black to prevent internal reflections; the large area behind the lens is occupied by the vitreous body. In front of the lens a small area is filled by aqueous humour, the two compartments being incompletely divided into the anterior and posterior chambers by the iris. The space bounded by the inner margin of the iris is the pupil.

The wall of the eye, enclosing the refractive media is made up of three coats. The outer coat is fibrous and consists of the sclera and cornea; a vascular coat, the choroid, ciliary body and iris; and the innermost nervous coat, the retina. The sclera can be considered as a ‘cup-like’ expansion of the dural sheath of the optic nerve. The choroid could be also considered as an expansion of the arachnoid and pia, while the retina being an expansion of the optic nerve.

Position of the globe

The anteroposterior position of the eyeball is controlled by the periorbital fat; the balance between the posterior pull of rectus muscles against the anterior traction of the oblique muscles; the integrity of check ligaments derived from the sheaths of medial and lateral rectus muscles and the atmospheric pressure and normal tissue hydration.

The vertical position of the globe depends primarily on the Lockwood's suspensory ligament. This is directly related to the fascial sheath of Tenon which closely surrounds the eyeball and separates it from orbital fat.

Ocular movements

The eyeball is moved by extraocular muscles; superior, medial and inferior rectus muscles are responsible for the inward, medial movement of the eye, while lateral rectus muscle and both oblique muscles are responsible for outward, lateral movement of the eye.

Because the medial and inferior muscles' long axes are not parallel to the long axis of the eye ball, the superior rectus turns the eye up and in, with the action of the inferior oblique muscle turning the eye up and out. The collective action of both muscles will result in pure upward movement of the eyeball. Inferior rectus and superior oblique have a similar collective action, resulting in pure downward movement.

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Chapter 2 Literature Review

2.1. Mechanism of blow-out fractures

The physical mechanism of orbital blow-out fractures has been debated for years by surgeons. Three main theories have been postulated, including the hydraulic theory, the contact of globe-to orbital wall theory, and the bone buckling theory.

In 1943, Pfeiffer reviewed 24 cases of “internal” orbital fractures with enophthalmos. He suggested that these fractures are results of transmission of the force of trauma directly from the ‘retropulsed’ globe toward the orbital floor (Pfeiffer, 1943).

A hydraulic theory was first proposed by King (1944): “The most ready explanation for orbital blow-out fractures is trauma transmitted through the eye to the orbital floor” (He *et al.*, 2007). Subsequent work by Smith and Regan (1957) demonstrated an experimental support for the hydraulic mechanism of blow-out fracture. Jones and Evans (1967) simulated the hydraulic mechanism on fresh human post-mortem cadavers. They subdivided the orbital floor into six zones of relative thickness. In their experimentally produced fractures, 79% occurred in the posterior medial floor. Their findings suggested that not only the thinness of the bone plays a “decisive “ role in the fracture, but the upward convexity of the posterior orbital floor receive the most force transmitted by the globe. The authors also confirmed that the anteroposterior axis along which the globe would move when pushed into the orbit is towards the posterior medial convex floor.

Another mechanism has been postulated by Fujino (1974) following an experimental study on dried human skulls without orbital content. Fujino suggested that direct compression or a buckling force is the causative factor for blow-out fracture. Fujino also reported that the force necessary to produce a blow-out fracture by pressure exerted on the globe is 10 times greater than the pressure required on the infraorbital rim. He argued that this amount of force applied to the globe would cause a high incidence of ocular injury.

These findings supported the theory first hypothesized by Le Fort, who also believed that orbital floor fractures were produced by the force of the injury transmitted through the orbital rim directly to the floor (Brown *et al.*, 1999).

Converse (1978) however, believes that the buckling theory does not explain fractures of the medial wall and it cannot easily explain soft tissue displacement or entrapment within the fractured walls of the orbit. However, Fujino and Makino (1980) with the use of high-speed photography showed that when a sudden force is applied to the infraorbital rim of an epoxy model of the orbit, a linear fracture of the orbital floor occurs through buckling caused by the posteriorly displaced infraorbital rim. This will tear the periorbita, and the orbital soft tissues are forced into the maxillary sinus by their attachment to the displaced orbital rim and floor, anterior to the linear fracture. Once the force is relieved, the bone springs back to the normal position, but the soft tissue does not return as quickly, causing an entrapment within the fracture.

Fujino and Sato (1987), in order to confirm the conclusion of the previous two-dimensional eye model, carried out an impact test utilizing a three dimensional eye model. Three kinds of eye models were made, consisting of orbital walls alone, orbital walls with orbital contents, but without the eyeball, and orbital walls, orbital contents and the eyeball. Three impact tests were performed; impact to the infraorbital margin, the eyeball or both the eyeball and infraorbital margin. They concluded that impact to the eyeball alone did not increase the infraorbital hydraulic pressure sufficiently enough to cause an orbital floor fracture. When the impact struck the infraorbital margin, the orbital floor was displaced laterally and finally fractured by the bending stress/buckling force.

Subsequent experimental and clinical studies have aimed to support either the “buckling” or “hydraulic” models. Kulwin and Leadbetter (1984) presented a case report supporting the theory that traumatic deformation of the bony orbital rims, without concomitant orbital soft tissue injury, can cause an orbital blowout fracture. The case reported was a 22 years old man who received trauma to his superior orbital rim causing a blow-out fracture toward the frontal sinus. Green *et al* (1990) constructed an apparatus that delivered a quantifiable force to the globe only, without involvementof the orbital rim, which was used on 11 anesthetized “Macaca fascicularis” monkeys. After orbital exenteration, the orbital walls and orbital contents were examined to determine the extent of injuries. Fracture of the orbital floor was produced at and above energy of 2.08 J. The study showed that orbital floor fractures can occur at low energies with direct ocular trauma only, a "pure" hydraulic mechanism, and was the first to demonstrate a quantifiable force required to produce a blow-out fracture. However, this was an animal model and higher percentage of globe rupture, 23% was noted. Phalen *et al* (1990) in their study on dried skulls and cadaveric specimens showed that minimal trauma to the orbital rim can produce segmental fracture without the presence of the globe. However they stated that the presence of the eyeball is necessary to produce a depressed fracture in the orbital floor.

Erling *et al.* (1999), in a study based on review C.T. scans of the orbital wall, supported the theory of direct globe-to-wall contact. They reported a globe "footprint" at the defect, suggesting a direct globe-wall contact. They stated that if the globe is displaced posteriorly, it can fracture the orbital wall. Bullock *et al* (1999) performed a clinical, experimental and theoretical study to investigate the two accepted (hydraulic and buckling) mechanisms for the blow-out fractures. Their findings provided support for each mechanisms of the orbital blow-out fracture from a clinical and theoretical basis. By using engineering formula for the hydraulic theory, they found that; the predicted theoretical energy is 71 mJ, and for the buckling theory is 68 mJ.

In the last decade, researchers have tried to overcome the limitations of previous studies, to provide a more supported conclusion about the real influence of each mechanism. Waterhouse *et al* (1999) drew the attention to the major flaws in the design and execution of previous experimental methods such as: "low numbers, unquantified forces, non-human models, incomplete soft tissues, poor simulation of in vivo conditions or a failure to isolate the position of the striking force". In their study they used fresh, intact unfixed human post-mortem cadavers; they directed quantifiable forces onto the same area on the infraorbital rim. The majority of fractures were located in the anterior and anteromedial aspects of the orbital floor. No medial wall involvement was observed and no herniation of the orbital contents into the maxillary antrum was reported. The same study investigated the hydraulic mechanism, using quantifiable forces confined to the globe. Fresh cadavers were again studied, and the intraocular pressure was quantified. They concluded that, fractures following trauma to the globe were located more posteriorly and posteromedially, with invariable medial wall involvement and frequent periorbital content herniation into the maxillary antrum. They demonstrated that the efforts to establish either mechanism as the primary aetiology have been “misplaced” and that both mechanisms produce orbital blow-out fractures. However, the fractures produced by each mechanism alone are different in their size, position and clinical significance.

Rhee *et al* (2002) carried out an experimental study on 5 cadavers, with support for the "hydraulic" theory against the role of direct globe-to-wall contact in the pathogenesis of orbital blow-out fractures. Their findings suggested that greater force to the orbital contents leads to greater damage to the orbital walls. Energy of 4,900 mJ and higher led to orbital floor fracture with herniation of orbital contents, whereas forces of 6,860 mJ and higher resulted in combination orbital floor/medial orbital wall fractures. These results imply that that the orbital floor has a lower threshold for fracture than the medial wall.

Nagasao *et al* (2006) produced three-dimensional models on a workstation simulating eight dry skulls and applied striking forces on the orbital rim of each model from three different angles (0, 15, and 30 degrees in the upward direction). They concluded that for the buckling mechanism, a wider area of fracture occurred when the striking force was directed upward than when the force was horizontally directed. They argued that this finding would be helpful in predicting fracture width in blow out fractures.

Ahmad *et al* (2003) used intact cadavers, quantifiable intraocular pressure, variable and quantifiable force, and quantifiable bone strain distribution with strain gauge analysis. Their study confirms the previous findings of Waterhouse et al, that the buckling mechanism produces fractures in the anterior and anteromedial aspects of the orbital floor without medial wall involvement. Furthermore, it confirmed that the hydraulic mechanism produced fractures distributed throughout the anterior and posterior parts of the orbital floor (Figure 2-1) with frequent medial wall involvement, in contrast to the buckling mechanism. They also found that herniation of the orbital contents is a feature of the hydraulic mechanism, as they did not observe herniation of orbital contents into the maxillary antrum following trauma to the infraorbital margin. They believed that herniation into the maxillary sinus is primarily due to the hydraulic pressure and not the effect of gravity, since herniation was still observed in supine cadavers. Their results also demonstrated that the mean energy required to produce a fracture with the buckling mechanism was (1.54 J) which is more than that with the hydraulic mechanism (1.22 J). This represents a disagreement with the findings of Fujino (1974), who found that the hydraulic mechanism required a force ten times that required by the buckling mechanism to produce a fracture.

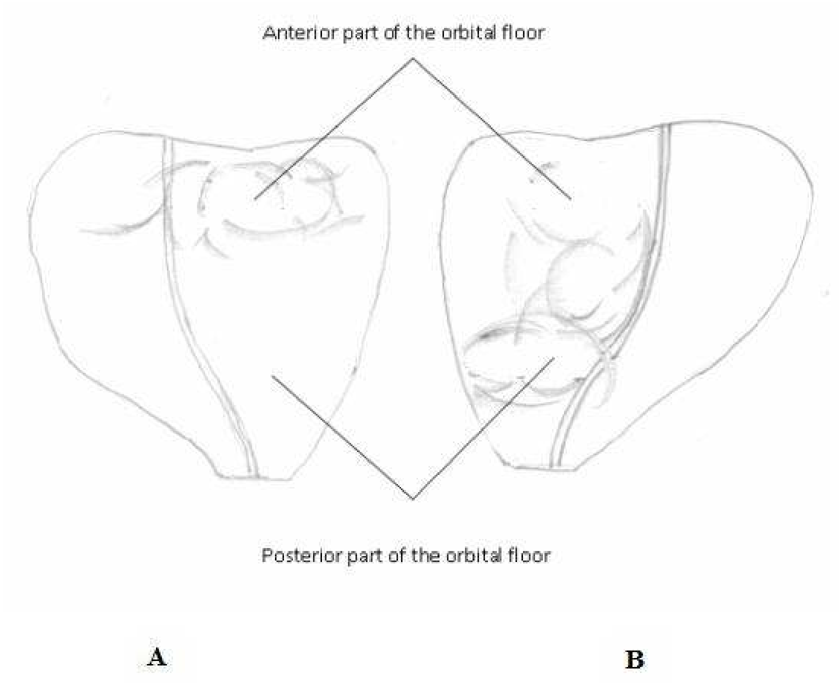

Figure 2-1: Templates demonstrating the combined fractures from all cadavers following (A) rim-directed and (B) globe-directed trauma. (Adapted from Ahmed et al 2003)

Ahmad *et al.* (2006) further supported the fact that efforts to establish one or another mechanism as the primary etiology are misplaced. Both mechanisms produce orbital blow-out fractures, with different and specific characteristics. They believed this provides the basis for reclassification of such fractures. He *et al* (2007) also agreed with the fact that both mechanisms play a role in blow-out fracture, because they found it unlikely for an object to hit the globe separately without hitting the inferior border at the same time, and they found that serious ocular injuries associated with blow-out fractures are uncommon (noted in 22% of cases) and this gives further credence to the buckling mechanism alongside the hydraulic mechanism. This would be in keeping with the fact that a low incidence of severe ocular injuries are observed in blow-out fracture patients: When the eye is struck by a large object, such as a clenched-fist, elbow or ball, the momentum of the force will be diffused and absorbed by the orbital margin, preventing severe ocular damage (Eagling, 1974). Chen *et al* (2009) consider that orbital blow-out fracture may involve both mechanisms. Interestingly, the authors suggested that the pyramidal structure and content of the orbit could generate a steep, transient rise in intra-orbital pressure when an external force is applied, causing deformation of the orbital walls. Furthermore, the impact of the external force is cushioned by orbital wall fracture, preventing damage to the globe. This might explain the finding of Kohlhof *et al* (2008) in a case report of complete dislocation of the globe to the maxillary sinus, with few injuries which were treated with satisfactory functional results.

Lee *et al* (2005) also agreed with concept of involvement of both mechanisms in most cases of blow-out fractures, and that it would be difficult on the basis of history taking and the knowledge of the cause to determine which mechanism is responsible. They stated, however, that for blow-out fractures in children, the buckling mechanism may be more applicable than hydraulic theory. Klenk and Kovacs (2003) explained the mechanism of blow-out fractures in small children on the basis of buckling theory, as they believed that in order to produce a blow-out fracture by the sudden increase of hydraulic pressure a greater force will be required because of incomplete pneumatization of the maxillary sinus (before 8 years of age). Criden and Ellis (2007) also explained the mechanism of trapdoor fractures with subsequent muscle entrapment in children's blow-out fractures using "buckling" theory. Their intraoperative examination of 12 children showed a linear non displaced fracture with an entrapped inferior rectus muscle with the surrounding soft tissue with no bone flap identified.

In conclusion, this literature review would suggest that there is reliable evidence that both hydraulic and bucking mechanisms can produce blow-out fracture of the orbit, but with different characteristics and clinical features. Presence of medial /and or large posterior blow-out fractures fracture; incidence of ocular injuries and orbital tissue herniation may suggest the likelihood of involvement of hydraulic mechanism. Whereas, it seems that the role of buckling mechanism is more evident in paediatric trapdoor blow-out fractures.

2.2. Classification of blow-out fractures:

It seems that there is no widely approved classification for blow-out fractures. Most of the available classifications are more likely attempts to establish CT scan criteria for blow-out fractures. The use of CT scan in classification of facial fractures in general has been discussed by Manson *et al* (1990), and a classification for the facial fractures suggested on the basis of CT scan findings (pattern of comminution and displacement) in addition to the anatomical location of the fracture.

In cases of blow-out fractures, however, CT scan findings have been interpreted in more than one way. A classification of blow-out fractures according to the relationship between the fracture edges and the inferior rectus on coronal CT scans was suggested by Gilbard *et al* (1985). Harris *et al* (1998) have classified blow-out fractures on coronal CT scans, and divided the patients by bone fragment configuration and soft-tissue distortion to reflect the severity of soft tissue damage into 3 general categories: "Trap-door" injuries, in which bone fragments with almost perfect alignment, were classified as type I fractures. Type II fractures involve bone fragment distraction with soft tissue displacement in between. In type III fractures, the displaced bone fragments are surrounding the displaced the soft tissue over the area of the fracture.   Ahmed et al (2003) stated that until now there is no clinically useful classification of orbital floor fractures. They classified blow-out fractures, based on their study of the mechanism of blow out fractures, into two categories; Type 1: a small fracture confined to the anterior to mid-medial floor of the orbit in which herniation of orbital contents is unusual. Type 2: a large fracture, usually, involving the entire orbital floor and medial wall, in which herniation of orbital contents is frequent.

Sawano *et al* (2005) classified the patients in their study into 3 different fracture types (trap door type, bone defect type and a 'muscle caught' type). Furuta *et al* (2006) classified orbital blow-out fractures as either (closed flap) or (open flap) at the floor and/or medial wall using CT scan image reconstruction. A closed flap fracture is a fracture with one or two edges. It includes; linear fractures, green-stick fractures, and trapdoor fractures.

Jaquiery *et al* (2007) suggested a classification for orbital wall defects basing on two dimensional schematic representations of the orbital walls in relation to coronal CT scan in to 5 categories depending on the site and the size of the fractures in relation to the 9 zones in the schematic circular representation of fracture (Figure 2-2).

A more recent classification suggested by Yano *et al* (2009), for the sake of simplicity of fracture description, divided blow-out fractures into: linear type, punched-out type and burst type. Linear fractures were used describe fractures with minimally dislocated bone fragments. Punched-out was used as a term for fractures involving less than one-third of the floor. Burst fractures are the fractures which involve more than two-thirds of the orbital wall. Poeschl *et al.* (2011) adopted the same classification, they used the "punched-out" fracture term for fractures less than half of the orbital floor, and the "burst" fracture term for fractures involving more than half of the orbital floor.

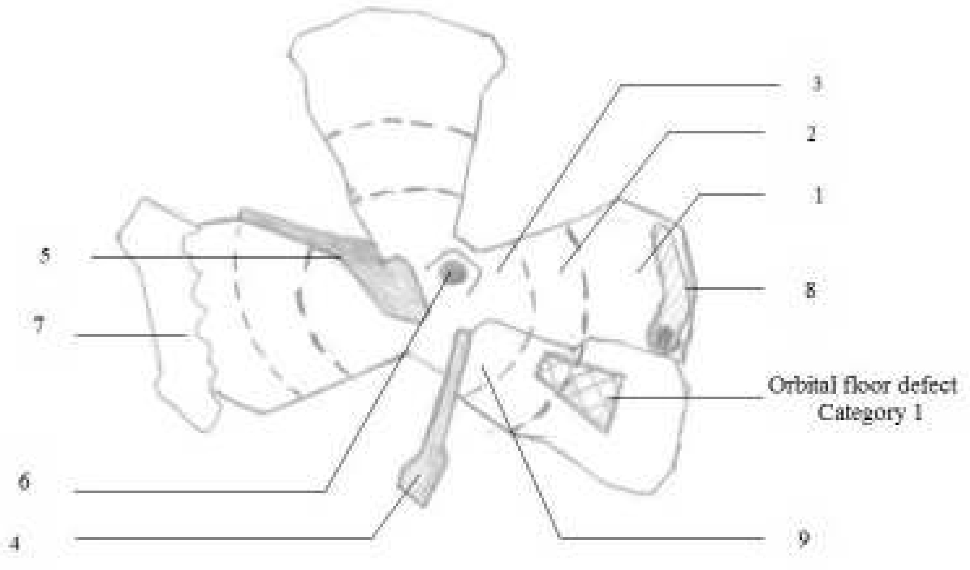

Figure 2-2: Orbital sketch: (1) orbital floor, anterior third, (2) orbital floor, middle third, (3) orbital floor, dorsal third, (4) infraorbital fissure, (5) supraorbital fissure, (6) optical nerve, (7) lateral wall, (8) naso-lachrymal duct, (9) medial border of the infraorbital fissure. (Adapted from Jaquiery et al 2007

2.2.1. Medial wall blow-out fracture:

All the previously mentioned classifications of blow-out fractures did not consider medial wall fractures. This might be related to the fact that isolated blow-out fractures of the medial orbital wall are uncommon (de Visscher and van der Wal, 1988), or because this type of fracture occurs more commonly with other orbital fractures. Burm *et al* (1999) found that the most common facial fractures associated with medial wall fractures were nasal fractures (51 percent), not inferior orbital wall fractures (33 percent). This finding suggests that the force causing nasal fractures is as an important causative factor of pure medial wall fractures as the buckling force from the medial orbital rim. Jank *et al* (2003) confirmed the high association of medial blow-out fracture with other types of fractures. Out of 424 patients they recorded only 1 patient (0.2%) with an isolated medial orbital wall fracture, whereas 357 patients (84.2%) had isolated blowout fractures of the orbital floor.

A blow-out fracture of the medial orbital wall should be suspected when periorbital trauma results in epistaxis, orbital hemorrhage, horizontal diplopia, dystopia of the globe, and/or orbital emphysema (Barone and Gigantelli, 1998).

Manson and Iliff (1991) found that medial muscle incarceration is not a feature in medial blow-out fractures despite muscle proximity to the medial wall, and isolated medial wall fractures primarily more responsible for orbital volume expansion. Biesman *et al* (1996) pointed out that combined orbital floor and medial walls fractures are usually associated with higher incidence of residual diplopia. Burm *et al* (1999) found that 25 percent of patients with medial blow-out fracture had diplopia and 40 percent had enophthalmos. They explained that poor motility outcome in patients with severe medial blow-out fractures being due to more bleeding from the ethmoid complex, which increases the possibility that orbital soft tissue will adhere to periosteum.

Jank *et al* (2003) advocate surgical reconstruction for medial blow-out fractures, as these fractures usually cause enophthalmos from increased orbital volume. In contrast to the above studies, they also found an increase incidence of diplopia because of medial rectus restriction, resulting in horizontal diplopia.

2.3. Incidence of blow-out fractures

Blow-out fractures of the orbit are relatively uncommon compared to other types of facial fractures. Ioannides *et al* (1988) recorded 59 isolated blow out fractures in a series of 509 patients with fractures involving the orbit, including zygomatic, nasoethmoidal, Le Fort II and Le Fort III fractures. Al-Qurainy *et al* (1991) in their 2 year prospective study of 363 patients who had sustained midfacial fractures found that 36 patients were presented with pure blow-out fractures of the orbit. Shantha Amritha *et al*.(2000) in their study on 104 patients with craniofacial injuries, found that blow-out fractures of the orbital floor and medial wall are the most common types of fracture (36% of the cases). Malara *et al* (2006) recorded 5 cases of blow-out fracture out of 198 patients with facial fractures due to road traffic collisions. Gosau *et al*. (2011) found that only 19.6% (n=37) had isolated orbital floor fractures out of 189 patients with various facial fractures,.

Baek *et al* (2003) studied a sample of 29 blow-out fractures found that fractures occurred most frequently between the ages of 20 and 29 years and were more common in males than females. Violence was the most common cause, and the most common fracture site was inferior wall combined with medial wall. Jones (1994) in his study on 62 patients with blow-out fractures, found that assault was the cause in 33(53%) cases, Sport 23(37%), Falls 3(5%), Road-traffic collisions 2(3%) and Work 1(2%).

Blow-out fractures of the orbital floor in children seem to be far less common, particularly in those less than 8 years old, due to anatomical differences. The preadolescent child presents with craniofacial disproportion, with an underdeveloped midface, small maxillary sinuses, and protruded cranium and mandible (Anderson and Poole, 1995). The “trapdoor” fracture is a common reported intraoperative finding of blow-out fracture in young patients in contrast to the “open door” fracture found in adults. Sires *et al* (1998) explained the association of (uncommon) trapdoor fractures with children and young adults, by the elasticity of the orbital bone in this age group, which allows the bone to return back quickly into position after it fractures and the soft tissue has already prolapsed through the fracture. That is why a small, non-displaced fracture is associated with orbital soft tissue entrapment in the maxillary sinus. This action may explain the late recovery of ocular motility in children after surgical treatment, as ‘strangulation’ of the herniated tissue may cause loss of muscular function (Theologie-Lygidakis *et al.*, 2007).

Egbert *et al’s* (2000) study found that children older than 12 years of age were more likely to sustain an orbital floor fracture as a result of interpersonal violence than children less than 12 years of age. Of their sample, 62% had a trapdoor type fracture. Bansagi and Meyer (2000) confirmed that trapdoor-type fractures, usually involving the orbital floor, are common in the pediatric age group. Kwon *et al* (2005) in their retrospective study of 70 patients (16 patients were children aged less than16 years and 54 were adults aged 17 years), which further supported the fact that trapdoor fractures were more frequent in the younger age group (n=13; 81%), whereas 30 patients (56%) had open-door fractures were more common in the adult group (30/56%). They also noticed that paediatric group had less severe periorbital swelling compared with the adults

To summarize; blow-out fractures of the orbit may constitute around 10% of mid face fractures. Although blow-out fractures are less likely to occur in small children, they frequently present with symptomatic trap-door type fractures. Interpersonal violence seems to be the most frequent cause of blow-out fractures.

2.4. Diagnosis and clinical findings of blow-out fracture

In a patient presenting with a history of blunt trauma to the orbit with resulting diplopia, the differential diagnosis should include orbital haemorrhage or oedema, extraocular muscle injury or cranial nerve palsy, in addition to blow-out fracture (Brady *et al.*, 2001).

An intact orbital rim may obscure the presence of a fracture in the orbital floor and the clinician should suspect the presence of blow-out fracture until proven otherwise (Rowe and Williams, 1994 ; Brady *et al.*, 2001)

Rowe and Williams (1994) listed the findings which would raise suspicion of a blow-out fracture, including: history and nature of the injury; the presence of immediate limitation of elevation of the eye, especially if this is not matched by the degree of restriction of movement in other directions; limitation of movement with an intact orbital margin and paraesthesia of the infraorbital nerve; and change in the ocular level. The authors also reported the ‘tear-drop’ sign or hemispherical opacity attached to the roof of the sinus on an occipitomental radiograph as indicative of a fracture. Furthermore, Brady et al (2001) stated that infra-orbital hypoaesthesia, or intraorbital emphysema also should raise the suspicion about the presence of blow-out fracture

Lerman (1970) stated that it is possible to predict the site of the fracture in relation to the equator of the globe on the basis of the motility defect. If the inferior rectus muscle is tethered anteriorly the eye will be fixed in a depressed position, resulting in a hypotropia on the side of the injury when the opposite eye in the primary position. This imbalance will be less marked when looking down and exaggerated when looking up. If the inferior rectus muscle is entrapped posterior to the equator of the globe, the eye will be fixed in an elevated position and in the primary position of gaze and hypertropia on the same side as the injury will result, so that the imbalance will be less on looking up and will be exaggerated on looking down.

In the same context, Seiff and Good, (1996) reported a subgroup of blow-out fractures cases with hypertropia. The CT scan showed a characteristic depressed fracture of the posterior orbital floor extending to the posterior wall of the maxillary sinus in all patients. In many patients, the inferior rectus was noted to be looped inferiorly resulting in a steep contact with the globe. No spontaneous recovery of diplopia was recorded in these patients. The authors concluded that if diplopia was recorded in association with hypertropia, a posterior blow-out fracture should be suspected and investigated by CT scan.

Blow-out fractures in children present with a different clinical picture, with a trapdoor type of fracture with marked restriction of ocular motility. de Man *et al* (1991) in their study on 50 patients reported 15 children with orbital floor blow-out fractures. 14 had trapdoor type of fracture with sever restriction of ocular motility. Jordan *et al* (1998) stressed that this type of blow-out fracture, commonly affecting children less than 16 years of age, shows marked ocular motility restriction in upward and downward gaze together with minimal soft tissue signs of trauma and absence of enophthalmos. These finding were associated with a minimal CT scan evidence of floor disruption. They termed this entity of blow-out fracture as ‘the white-eyed' blow-out fracture.

Trapdoor fractures in children which are small with minimal soft-tissue entrapment, can make the interpretation of CT quite difficult Bansagi and Meyer (2000). Wachler and Holds (1998) termed the characteristic absent inferior muscle in coronal CT , associated with small blow out fractures “the missing muscle syndrome”.

Bansagi and Meyer (2000) also reported that marked motility restriction and nausea/vomiting were strongly suggestive signs of a trapdoor-type fracture and an indication for immediate surgical intervention. Tachycardia nausea and vomiting associated with muscle entrapment are the result of an oculocardiac reflex, due to stimulation of the ophthalmic division of the trigeminal nerve. The impulses from the ophthalmic division pass through the reticular formation to the vagus nerve's visceral motor nuclei with subsequent effect on the heart and stomach.

2.4.1. Binocular diplopia

Diplopia occurs as a result of stimulation of non-corresponding points of the two retinas by the same object (McGill, 1974). Diplopia is a common complication in blow-out fractures of the orbit. The incidence of diplopia in orbital blow-out fractures, as reported in the literature, ranges from 58%-84% (Hammerschlag *et al.*, 1982; France, 1994; Biesman *et al.*, 1996; Shantha Amritha *et al.*, 2000; Brady *et al.*, 2001; Hosal and Beatty, 2002). Diplopia is often caused by vertical motility impairment in blow-out fracture which is the most common ocular motility disturbance associated with trapdoor fractures (Bansagi and Meyer, 2000).

Evaluation of diplopia in the immediate post-traumatic period is invaluable in decision making for the management of blow-out fracture patients (France, 1994). As an initial clinical assessment , the clinician may use a linear light and ask the patient to focus his eyes and follow the light in the nine cardinal positions of gaze where they perceive a double image (Stassen and Kerawala, 2007).

The direct cause of diplopia in blow-out fractures is a debatable issue. Some authors believe that direct muscle injuries resulting in haematoma, oedema and subsequent fibrosis, or nerve injury are more likely to be the causative factors for diplopia in blow-out fractures as opposed to entrapment of muscles or fascia (Putterman *et al.*, 1974; Koornneef, 1982). Late motility problems are suggested by these same authors to be caused by fibrosis due to oedema, haemorrhage, or denervation.

Dutton (1991) stated that poor motility is most commonly due to direct muscle contusion but may represent entrapment. Putterman (1991), suggests that the extraocular muscle motility problems and infraorbital anaesthesia resulting from the fracture frequently improve, but enophthalmos and hypophthalmos either persist or worsen as the oedema and haemorrhage subsides.

Harley (1975) referred to the neurogenic causes of persistent diplopia. He demonstrated the possibility of damage to the nerve entering the inferior rectus in posterior fractures. Wojno (1987) referred to the importance of direct injury to the extraocular muscles (EOM) or the nerve supply. He found of 40 blow-out fracture patients studied prospectively, 7 had motility disturbances consistent with palsy of one extraocular muscles or cranial nerve. All seven patients had negative forced duction tests, making entrapment, oedema, or orbital hemorrhage unlikely causes of diplopia. The diplopia resolved in four patients within 1 year. Persistent diplopia is a common indication for repair of such fractures. If, however, diplopia is due only to extra ocular muscle or nerve palsy, orbital surgery should be deferred (in the absence of significant enophthalmos) in favour of observation and/or later strabismus surgery. Demer (2001) reported that the recovery of contused extraocular muscle or its motor nerve may take months and that MRI will provide definitive information about the structural integrity of the affected muscle after 3 to 6 months. On the other hand, if diplopia is caused by orbital oedema and/or mild muscle contusion, with no evidence of trapdoor muscle entrapment or transection, a period of 1-2 weeks for careful observation is advisable as resolution of pain and oedema will allow a more conclusive opinion (Criden and Ellis, 2007).

Ludwig and Brown (2001) demonstrated a group of patients who had avulsion-type flap tears of the extraocular muscles, after blunt trauma to the orbit (some with a CT scan evidence of fractures whilst others did not); they considered this phenomenon one of the common causes of strabismus after trauma. Intraoperatively the torn “flap” of muscle was found external to the muscle, scarred into surrounding orbital connective tissue and fat. They also observed that sometimes several small flaps were avulsed as opposed to a solitary flap. As the muscle tear was not expected and was overlooked in CT scan, a long time often elapsed before treatment was undertaken. The authors also noticed that in some of patients the tear was distant from the fracture. To explain this phenomenon, anatomic studies were carried out which showed 2 distinct layers in the extra ocular muscle: (1) the global layer, adjacent to the globe, and (2) the orbital layer. They hypothesized that the sudden downward force experienced by the orbital contents at the time of blunt trauma may exert a traction effect on the orbital layer of the muscle, tearing the orbital from the global layer. Yip *et al* (2006) reported an unusual case of inferior rectus muscle transection after uncomplicated blow-out fracture repair. They suggest that MRI can be used to assist in precise management of such cases and avoid prolonged periods of observation.

Rowe and Williams (1994), on the other hand, suggested that diplopia is a multifactoral problem. The authors suggested that blood or bony spicules, avulsion of the muscle from the bone, incarceration of orbital fat or of the extraocular muscles in the fracture line and fibrous adhesions between the muscle and the orbital fat or periosteum, could cause physical interferences with the extraocular muscle action causing diplopia. They stated that diplopia occurs with inability for compensatory mechanisms to deal with considerable degrees of alteration in the visual axis as a result of trauma, aggravated by compensatory over-activity of the unaffected muscle in the other eye. They pointed out that in the majority of cases of diplopia, failure in eye movement is not because of the paresis of the moving muscle but the inability of the counter- acting muscle for relaxation due to the fibrosis between its sheath and the adjacent periosteum in the fracture site. A common example in blowout fracture is the inability of superior rectus muscle for upward movement due to the adhesion between the inferior rectus muscle and the floor of the orbit.

Variable degrees of tissue involvement in the fracture defect have been suggested by other authors to have a major influence on diplopia. Gilbard *et al* (1985) used axial and coronal CT scans to classify the pattern of inferior rectus muscle entrapment in the orbital floor into free from entrapment, hooked, and entrapped, according to the continuity of the muscle with bony density in “no area”, “along one side”, or “along both nasal and temporal sides”. They stated that patients with CT scan evidence of bone fragments adjacent to the inferior rectus muscle on both sides have high risk for developing diplopia, while CT scan evidence of hooked muscles (the inferior rectus muscle adjacent to a bone fragment on one side) had less diplopia and those with free inferior rectus muscles had no diplopia. Harris *et al* (1998) in their study on the predictive value of preoperative CT scan findings, attributed the poor motility outcome by the damage of the fibrofatty-muscular complex to a varying degree as it is driven between bone fragments, with subsequent intrinsic fibrosis and contraction tethering globe movement.

Classification of the severity of diplopia also has been debated in the literature. Hammer *et al*(1995) and Harris *et al* (1998) described mild, moderate and severe diplopia; suggesting that only moderate and severe diplopia are clinically important. Diplopia is considered severe when it is present in all positions; moderate when present in vertical fields of gaze; and mild when only in the extremes of gaze.

Eeckhoutte *et al* (1998) in their study on 14 patients who underwent strabismus surgery for persistent diplopia, believed a comfortable field of binocular single vision to be within 20 degrees upward to 30 degrees downward gaze, and Hosal and Beatty (2002), within 30 degree of the primary position. Jaquiery *et al* (2007), using Hans Target Screen, considered no double vision within 20 degrees postoperatively to be good and within 10 degrees to be satisfactory and double vision in all gazes to be poor. They based this on a driving safety protocol for driving in Switzerland, as it permits motor driving for patients who are free from double vision at 20 degree at all gazes on Hans Target Screen. Cope *et al* (1999) considered the definition 'troublesome diplopia,' which is dependent on patient perception rather than measurement of ocular movement, to be most relevant definition. Similarly, Sleep *et al* (2007) defined relevant diplopia as being diplopia in the primary position or of importance in daily life and not just limited to the extreme of gaze.

In summary, this literature review suggests that the aetiology of diplopia is likely to be multi factorial. However, it would appear that a combination of orbital soft tissue injury and variable degrees of tissue involvement in the fracture defect are the most probable causes for diplopia in blow-out fracture of the orbit.

Subjectivity of diplopia and absence of a unifying quantitative measurement of diplopia make the assessment and discussion of diplopia severity problematic.

2.4.2. Enophthalmos

Enophthalmos is a posterior displacement of the eyeball within the orbit in an anteroposterior plane (Cline and Rootman, 1984). Rowe and Williams (1994) defined enophthalmos, as a disturbance in the balance between the periorbital fat and the orbital walls. Enophthalmos is common complication of blow-out fractures of the orbit, with a reported incidence range from 30% to 62% (Jayamanne and Igillie, 1995; Hosal and Beatty, 2002; Barry, 2005; Wang *et al.*, 2008).

The main focus of research regarding enophthalmos has been directed towards the pathophysiology of this complication and the possible influential factors. Rowe and Williams (1994) explained the reason behind enophthalmos by the increase of the orbital volume by outward movement of one or more orbital walls or a decrease in the quantity of orbital fat by herniation into adjacent spaces such as the antrum, infratemporal fossa and the ethmoidal air cells. They term this loss ‘relative loss’, absolute loss being the liquefaction or fibrosis of the orbital fat. They stated that the degree of post-traumatic enophthalmos is related to the degree of change in the orbital volume. However, Hammerschlag *et al* (1982) stated that, in the acute phase of the trauma, enophthalmos can only result from prolapse of orbital contents into adjacent sinuses.

Manson *et al* (1986) found that loss of intramuscular conal fat (atrophy or displacement), in both cadavers and patients, produced enophthalmos. They also found that atrophy is not a prominent feature in most patients with post-traumatic enophthalmos. They concluded that the principal mechanism in post-traumatic enophthalmos involves both displacement and change in the shape of the orbital tissue. They suggested that enophthalmos is caused through both bony enlargement of the orbit and ligament disruption. Due to the loss of bone and ligament support of the globe remodelling and fibrous scar contracture may occur. As a result a change in the shape of retrobulbar content from conical to spherical will result, which in turn will allow the eyeball to sink backwards and downwards.

Manson and Iliff (1991) believed that the loss of extraconal fat will not cause significant change in the globe position. However, loss of intraconal fat or displacement into the extraconal space will result in loss of globe support, aided by a weak ligament system in the posterior orbit, and easy extrusion of the intraconal fat to the extraconal space. They argued that fat atrophy is the probable cause for enophthalmos in only 10% of patients. Hence, the key to successful repositioning of globe of the eye is restoration of orbital volume. Furthermore, they stated that early globe position does not predict late globe position because of oedema. Moderate orbital enlargement on CT may predict development of enophthalmos when the swelling subsides.

Pearl (1998) suggested that defects of the anterior orbital floor, anterior to the equator of the globe, do not produce enophthalmos as the size of the defect is frequently too small to cause eyeball displacement, whereas fractures of the posterior orbital floor are more likely to produce enophthalmos because of greater volumetric loss behind the equator.

Hamedani *et al* (2007) summarized the pathophysiology of enophthalmos in orbital trauma was the result of one of three factors: enlargement of orbital "container", reduction of orbital content and contraction of orbital content. They stated that enlargement of the orbital container seems to be the most frequent cause of enophthalmos. Clauser *et al* (2008) also considered orbital enlargement as the primary cause for enophthalmos. However, they mentioned soft tissue involvement such as herniation of orbital fat into the maxillary sinus, fat atrophy, loss of ligament support and scar contracture as other causative factors.

Since the mid-eighties, research has concentrated on the major role played by orbital volume changes on enophthalmos. However, some argued that enophthalmos might occur with no significant orbital volume changes as demonstrated by CT scan. Putterman (1991) pointed out that there was no evidence to support that the size of the orbital fracture on CT scans or radiographs correlates with the amount of enophthalmos or hypophthalmos. Smith *et al* (1998) stated that enophthalmos can occur even with minimally displaced fractures in the orbital floor when it involves the inferomedial convexity. Furthermore, according to Hartstein and Roper-Hall (2000), not all patients with large fractures of the floor over (50%) necessarily develop enophthalmos.

Hawes and Dortzbach (1983) suggested that fractures involving more than 25% of the floor, based on CT imaging, increase the likelihood of enophthalmos, and fractures with CT evidence of more half of the floor missing would result in more significant enophthalmos. The authors advocate early repair in these situations, even in the absence of clinical enophthalmos. Gilbard *et al* (1985) believed that CT evidence of a fracture involving over half of the floor would increase the likelihood of developing enophthalmos, but they include the increase of the chance of development of diplopia.

Many studies have attempted to correlate orbital volume measurements from CT with enophthalmos; Bite *et al* (1985) did a CT scan analysis on 11 patients to measure total bony orbital volume, detailed soft tissue volume and apex-to-globe distance in the horizontal plane. Their analysis demonstrated a statistically significant increase in bony orbital volume in the enophthalmic eye, and that the total soft-tissue volume of the orbital contents was the same as in the normal eye. Their results suggested that post-traumatic enophthalmos in the majority of patients results from the increased bony orbital volume, not soft-tissue loss or fat necrosis. However, they reasoned that enophthalmos in cases with no orbital volume discrepancies was due to cicatricial contracture. They stated that correction of enophthalmos should be directed to decrease the volume of the bony orbit and to increase the anterior projection of the globe, which is the same concept reported much earlier by (Devoe, 1947).

Whitehouse *et al* (1994) performed a CT study on 25 patients with blow-out fractures. They found that a 1cm^3 increase in orbital volume causes 0.8 mm of enophthalmos, confirming that the cause of enophthalmos after blow-out fracture is orbital volume increase rather than fat atrophy or fibrosis. Their results also showed that within 20 days of injury, up to 3 mm of enophthalmos may be obscured by retrobulbar soft tissue swelling and that this effect may still be apparent up to 20 days after injury. Dolynchuk *et al* (1996) in their study on patients with orbitozygomatic fractures, using software analysis for both coronal and axial CT scans, considered 4% increase in orbital measurement as the critical volume difference at which enophthalmos becomes clinically noticeable. Yab *et al* (1997) in a CT scan analysis of 32 patients with blow-out fractures, found enophthalmos remains around 1 mm until total orbital enlargement reaches 2 ml in volume, after which it increases proportionally with total orbital enlargement until 4 ml, then plateaus. They also demonstrated a proportional relationship between enophthalmos and medial displacement of the eyeball, but not between enophthalmos and inferior displacement of the eyeball. Raskin *et al* (1998) did a volume analysis based on CT scans of 30 patients with blow-out fractures. They found that early Hertel's measurements[1] (less than 4 weeks) did not correlate with the computer volumetric values or with subsequent late enophthalmos.

Jin *et al* (2000) found a significant relationship between enophthalmos and increase in fracture area and the volume of the herniated tissue. They conclude that enophthalmos of 2 mm or more, which is a frequent indication for surgery, can be expected when the area of fracture is 1.9 cm^2 or more, or the volume of herniated orbital tissue is 0.9 mL or more. Fan *et al* (2003) in a study of 16 patients with blow-out fractures found a high correlation between the increment of orbital volume and the degree of enophthalmos, reporting that an increase of orbital volume of 1cm^3 causes 0.89 mm of enophthalmos.

Cunningham *et al* (2005), tried to establish the relationship between enophthalmos, linear displacement, and volume change for various patterns of experimentally created orbital fracture. They found that the displacement of 1 and 2-walled orbital defects results in a direct and linear change in both orbital volume and enophthalmos, regardless of the location of the defect.

Orbital volume measurement before early reconstructive surgery in cases of large fracture has also been recommended by (Juan *et al.*, 2006), to predict possible enophthalmos. Kokemueller *et al* (2008), using a measurement protocol involving spiral CT data in combination with image fusion techniques, analysed the degree of a persisting enophthalmos and its origin. They stated that their measurement protocol is especially suitable for long-term follow-up regarding changes of the bony orbit and its contents in trauma patients.

Kolk *et al* (2009) believed that 3-D orbital volume measurement is essential for the identification of post-operative and post-traumatic orbital volume changes and consequent degree of enophthalmos. Their data, derived from 3-D MRI 3–4 months

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[1] The Hertel exophthalmometer measures the corneal apex with a reference cone within the device to note the corneal alignment on a millimetre scale O'Donnell NP, Virdi M, Kemp EG (1999). Hertel exophthalmometry: the most appropriate measuring technique. *Br J Ophthalmol* 83:1096B..

after surgical reconstruction of the fracture, showed that all enophthalmic orbits revealed a significant bony volume increase, as well as a reduced sagittal eye projection compared to the contralateral side. Mean orbital volume enlargements of 1.0 cm^3 lead to 0.93 mm enophthalmos, a value similar to that of Whitehouse *et al* (1994) and Fan *et al* (2003). The authors could not detect fatty atrophy by different techniques of MRI.

Although the majority of research about enophthalmos prediction focused on orbital volume changes, some researchers studied the influence of extra ocular muscle configuration as determined by CT scan on enophthalmos. Kim *et al* (2008b) in their analysis on 24 patients with untreated medial blow-out fractures found that the height-width ratio of medial rectus muscle in coronal CT scan is a useful parameter to predict enophthalmos, and a value of over 0.7 requiring surgical correction. Matic *et al* (2007) suggested that rounding of inferior rectus muscle in coronal CT scan has a predictive value for enophthalmos. They found that if the height to width ratio of the inferior rectus muscle is greater or equal to l.00, this will imply a late enophthalmos.

2.4.3. Subconjunctival haemorrhage and circumorbital ecchymosis:

Subconjunctival bleeding can occur in trauma confined to periorbital tissue. In the case of orbital fracture, blood starts to accumulate in the extraconal space then tracks anteriorly; this will appear as a posteriorly unbordered subconjunctival haemorrhage, a helpful diagnostic sign. Initial absence of subconjunctival haemorrhage, however, does not exclude the presence of fracture, as in some cases there will be no tearing in the periorbita, blood from the fracture slowly accumulating under the periorbital plane, which may take days to manifest on the conjunctiva (Rowe and Williams, 1994).

Circumorbital ecchymosis is a common sign in trauma to the pre-septal soft tissue. Tissue laxity allows free tracking of blood through the loose subcutaneous areolar tissue. The extravasated blood may remain for several weeks. Although in itself requiring no treatment, further investigation should be carried out to rule out more serious injuries (Stassen and Kerawala,(2007).

2.4.4. Infraorbital paraesthesia:

Infraorbital paraesthesia is a result of infraorbital nerve injury whether outside the infraorbital foramen or within the infraorbital canal. The presence of infraorbital anaesthesia without clinical evidence of fracture in the inferior orbital rim should raise suspicion of the presence of blow-out fracture (Rowe and Williams, 1994).

The incidence of post-traumatic infraorbital sensory disturbances ranges from 24.4% to 84 %. (Schultze-Mosgau *et al.*, 1999; Peltomaa and Rihkanen, 2000). Jayamanne and Igillie (1995) in a series of 45 patients with blow out fractures, reported a 20% incidence of infraorbital anaesthesia. Boush and Lemke (1994) reported 2 cases of blow-out fractures with severe, progressive infraorbital nerve hypoaesthesia. They suggested that progressive infraorbital nerve hypoesthesia should be considered a primary indication for blow-out fracture repair in selected patients in whom hypoaesthesia is severe.

2.4.5. Periorbital emphysema:

Periorbital emphysema is a benign, transient collection of air associated with small orbital fractures communicating with the paranasal sinuses. This sign may be detected by a ‘crackling’ sensation on palpation of the bony orbit. The collection may also manifest as a 'pneumogram', which outlines the globe of the eye in plain radiography (Rowe and Williams, 1994). Although benign, large collections have the potential to cause central retinal artery occlusion, and should be managed appropriately (Hunts *et al.*, 1994). Patients with orbital fractures should be instructed to avoid Valsalva’s manoeuvre, such as nose blowing, to avoid orbital emphysema (Marsden, 2002).

2.4.6. Ophthalmic injuries associated with blow-out fractures (intraocular injuries):

A direct blow to the eye and the surrounding tissue will result in a contusional injury of varying severity; from “black eye” to severe intraocular disruption. When the eye is struck, an anteroposterior compression will result with concomitant stretch in the equatorial plane with subsequent contusional and tearing damage, as shown in Figure 2-3.

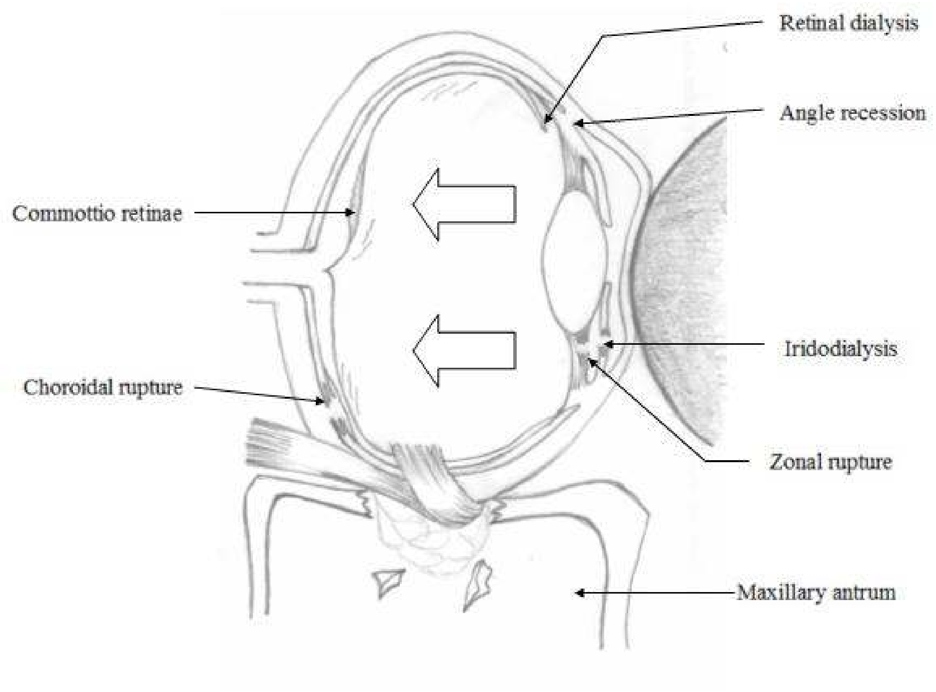


Figure 2-3: Blunt trauma to the eye results in a well recognised pattern of injury. (adapted from Macewen 1999).

The consequences following the strike result in flattening of the cornea and an immediate rise in intraocular pressure. As the anterior chamber is compressed, the pupil can be forced to dilate rapidly with subsequent tear of the sphincter muscles of the iris (traumatic mydriasis). Furthermore, the aqueous humor will be forced to the periphery and damage the drainage angle, resulting in glaucoma. Tension on the peripheral iris may result in displacement from its root, into the vitreous (Iridodialysis). Iridodialysis manifests as a D-shaped pupil. The condition shows little tendency to heal, but does not affect the sight. Additionally, bleeding from these highly vascularised structures will result in hyphaema, which is an accumulation of the blood in the anterior chamber (Macewen, 1999). Hyphaema is usually minimal and patients are advised to rest to avoid secondary bleeding. Injuries to the lens include contusional cataract or lens dislocation which is usually partial.

Choroidal tears may result in loss of vision from vitreous haemorrhage if large. Retinal haemorrhage may be single or multiple with variation in size, with obvious effects on vision. Retinal tears commonly occur at the anterior margin of the retina and may result in retinal detachment which may spread and affect the macula. The most common cause of visual disturbance in concussional eyeball injuries is retinal oedema (commotio retinae). It is usually resorbs spontaneously with residual pigmentation (Stassen and Kerawala, 2007).

The incidence of ocular injuries in association with periorbital fractures led several authors to acknowledge the importance of ophthalmological examination of patients with periorbital fracture during initial assessment (Ioannides *et al.*, 1988; Brady *et al.*, 2001; Barry *et al.*, 2008). The ophthalmic examination should include the pupil shape, size and the intraocular pressure, with an oval pupil or a pupil lying eccentrically suggesting blunt trauma or perforation of the globe. If the intraocular pressure increases above the normal level (10-22mm Hg) this may suggest glaucoma secondary to trauma. Intraocular pressure lower than 10 mm Hg suggests either perforation of the globe or hypotony which results from blunt trauma. The authors also stressed the importance of intraocular pressure measurement after the orbital fracture reduction. Similarly, al-Qurainy *et al* (1991) suggested that all patients sustaining mid-facial fractures associated with a significant decrease in visual acuity either pre or post-operatively should have early ophthalmological review.

Ophthalmic injuries are more frequent with pure blow-out fractures compared with other types of orbital fractures. Barry *et al* (2008) in their retrospective study on patients with orbitozygomatic complex fractures, found that ocular injuries in blow-out fractures of the orbit are more common than impure (simple and comminuted orbito- zygomatic) fractures, Brown *et al* (1999) also found of the patients who sustained a pure orbital floor fracture; intraocular injuries occurred in 5.6%, compared to only 2.0% in patients sustained an impure fracture.

There is no consensus regarding the severity of ocular injuries in blow-out fractures of the orbit. Jayamanne and Gillie (1995) suggested that severe ocular injuries are uncommon in patients with pure orbital blow-out fractures. Whereas, France (1994) recorded two cases of 21 cases with blow-out fractures presented with no light perception. Jayamanne and Gillie (1995) in their retrospective study of 45 patients found that the final visual outcome of patients with pure orbital blow-out fractures was excellent, with 43 (96%) patients having a visual acuity greater than 6/9 at discharge. Out of 45 patients they recorded the following ocular injuries: 3 conjunctival injuries, 3 hyphaema, 3 commotio retinae, 2 traumatic mydriasis, 1 corneal abrasion,1 traumatic optic neuropathy and 1 choroidal rupture. They stated that most of the ocular injuries were transient and of no permanent consequence, with the exception of the traumatic optic neuropathy, which is uncommon, but potentially serious complication. He *et al* (2007) found that the most common ocular finding in their study was commotio retinae, which was present in 21 of 60 globes (35%), followed by traumatic mydriasis, 32%, and traumatic iritis, 25%. Most ocular injuries were minor.

Monocular diplopia may occur with direct damage to the globe, including detached retina, dislocation of the lens, and damage to the macula. Although it is far less common than binocular diplopia, it should always be considered and excluded on examination (Rowe and Williams, 1994 ; Stassen and Kerawala, 2007).

2.5. Radiographic examination

2.5.1. Plain radiography:

The occipitomental view is the standard plain radiographic projection for orbital fractures. The central ray of the X-ray beam should pass though the nasal spine to project the top of the petrous temporal bones just below the floor of the maxillary sinuses to display the whole of both sinuses. This projection demonstrates fractures of the maxillary sinuses, orbits and zygomatic arches (Rowe and Williams, 1994).

Plain radiography can provide indirect evidence of orbital blow-out fracture by the presence of an air-fluid level. They give no definitive information on the status of the soft tissues (Hartstein and Roper-Hall, 2000) and cannot identify the exact relationship of the fracture and soft tissue incarceration. This led many surgeons to recommend surgical intervention in all blow-out fractures, even in the absence of conclusive radiographic findings (1991).

Inability of plain radiography to identify some of blow-out fractures has been mentioned in the literature. Dulley and Fells (1974) found that plain X-rays were able to identify 76.5% of the conservatively managed cases in their series. Chen *et al* (2009) compared the accuracy of plain X-ray in the diagnosis of blow-out fracture with CT scan and found that it was 52.6% (10/19) in plain radiography, while it was

73.7% (42/57) in cranial CT examination.

2.5.2. Computed tomography (CT scan)

The use of CT is now commonplace in the investigation of blow-out fractures. The nature of investigation does not only include its usefulness in the diagnosis of orbital fractures, but for its value in classification of blow out fractures of the orbit.

Manson and Iliff (1991) cited the criteria for proper evaluation of an orbital injury, as an axial scan, beginning at the superior aspect of the frontal sinus and progressing through the entire orbit terminating at the maxillary alveolus. Coronal sections should begin anteriorly at the nasal pyramid and continue posteriorly through to the orbital apex. CT scan can demonstrate in both axial and coronal planes the extent of the fractured floor and its relationship to the soft tissue (Hartstein and Roper-Hall, 2000).

Charteris *et al* (1993) referred to the potential importance of CT scan measurement in patients with blow-out fractures. They advised coronal CT scan, in particular, for post-operative assessment of the quality of orbital volume reconstruction. Baek *et al* (2003) also found the estimation of fracture size by using CT was more predictive of late post-operative enophthalmos. Hamedani *et al* (2007) stated that CT volumetric measurement with digital reconstructions may be useful for the predictive diagnosis of late enophthalmos and the quality of surgical reconstruction. They believe that axial, coronal and sagittal CT scans are valuable in assessing the location and the extent of the fracture with soft tissue involvement, and plain radiography should be avoided. However, they suggested that MRI may aid in the diagnosis of muscular fibrosis.

Santos *et al* (2007) reported that axial and coronal CT scans are adequate for diagnosis of medial orbital wall fractures, with coronal CT being superior for the detection of orbital floor fractures and for the adequate assessment of the cribiform plate and orbital roof. However, such examinations may not be practical for patients with intracranial injuries and cervical fractures.

Harris *et al* (2000) pointed out that three-dimensional orbital imaging provides reliable assessment of the position and extent of wall deformities, involvement of orbital soft tissues, and ocular position before and secondary to fracture reconstruction. Ploder *et al* (2001) applied a software program on coronal CT scans to measure the orbital floor and the fracture area. They found that the distances to the medial and lateral boundary of the fracture can be successfully measured on each CT slice. Furthermore, they measured the size of the dislocated fragment and the extent of soft tissue herniated into the antrum.

Furuta *et al* (2006) studied the number of points of muscle contact with the orbital fracture site on CT along with Hess Area Ratio (HAR) for measurement of extraocular muscle function. They analysed 113 cases of blow-out fracture with diplopia and found that both clinical manifestation and prognosis could be approximately predicted on the basis of number of muscle contact points with the fracture margin. Furthermore, they stated that treatment decision should be guided by thorough evaluation of the CT scan.

More recently, Higashino et al (2011) studied the CT scan findings of 106 cases with blow-out fractures. They found that all patients had diplopia when the fracture width was less than half of the eyeball diameter, and when inferior rectus muscle herniation into the maxillary sinus was half or more than half of its section. They also found that this level of protrusion of inferior rectus muscle might result in enophthalmos, even if the fracture width was less than half the diameter of the globe. Accordingly they suggested a CT scan based algorithm for treatment of blow-out fractures.

Nevertheless, there is some evidence in the literature which suggests a limited value of CT in some cases of blow-out fractures of the orbit. Hammerschlag *et al* (1982) believed that direct coronal CT scans are inadequate for evaluation of orbital blow-out fractures. Putterman (1991) argued that there is no necessity for routine CT scans in blow-out fracture, the author ordering them selectively to aid in differentiating an entrapped inferior rectus muscle from a contused inferior rectus muscle, or for evaluation of the size of the implant needed to treat late enophthalmos. Charteris *et al* (1993) in their CT scan volumetric analysis of 31 patients with blow-out fractures stated that there is no absolute value of volume discrepancy provided by CT scan which can be given as an indication for surgery.

Sandler *et al* (1999) advocate the use of transantral endoscopy under local anaesthesia as a useful clinical aid in diagnosis of blow-out fracture, because of the disadvantages and limitation in the accuracy of CT scans. Farwell *et al* (2007) stated that in most of their cases (53), endoscopic, intraoperative findings demonstrated that the size of herniated orbital tissue into the maxillary antrum was larger than would be appreciated by CT scan. They agreed with Saunders et al (1997) on the fact that CT scan may not accurately quantify the size or extent of injuries.

Yoon *et al* (2003) and Theologie-Lygidakis *et al* (2007) found that trapdoor-type fractures with minimal soft tissue incarceration may sometimes be difficult to see, even in CT scans. This finding was supported by Criden and Ellis (2007) in their review of the radiologist's interpretation of the CT for 12 cases of white eyed blow-out fractures. They demonstrated that a fracture was identified in only nine of the twelve known cases. Radiologists identified entrapped inferior rectus muscles in only three of the known cases and the reports were unclear in three other cases. Moreover, Parbhu *et al* (2008) provided strong evidence that there is underestimation of soft tissue entrapment by CT compared to clinical examination and intraoperative findings in the paediatric population. They found that more than 50% of the children in their study had entrapment of orbital soft tissue that was not appreciated by the radiologist on the CT scan; therefore, they stress the importance of performing a thorough clinical examination and correlating this with the CT scan findings.

There are other imaging techniques that have been used for diagnosis of blow-out fractures of the orbit. These are Magnetic Resonance Imaging (MRI), Cone Beam CT (CBCT), and ultrasonography (US). Hui-Chuan *et al* (2007) stated that high resolution MRI can provide important information in oculomotor palsy regarding anatomical abnormality, compressive lesions in the path of the oculomotor nerve, and associated cranial nerve palsy. Furthermore, high resolution MRI can indicate the degree of atrophy of affected extraocular muscles. They suggested that it may be clinically valuable in selected, complex cases to employ high resolution MRI to see the path of the oculomotor nerve from brain stem to the individual extratorcualr muslces. Kolk *et al* (2009) suggested the use of high resolution MRI with an orbital coil as an alternative for CT scan in diagnosis of paediatric orbital fractures as muscle incarcerations could not always be diagnosed in CT scan. This agrees with Yoon *et al* (2003), Theologie-Lygidakis *et al* (2007) and Parbhu *et al* (2008).

Drage and Sivarajasingam (2009) described the use of cone beam computed tomography (CBCT) for use in isolated fractures of the orbital floor as it shows defects in the orbital floor with a lower dose of radiation than conventional computed tomography.

Jank *et al* (2004) investigated the diagnostic value of US in orbital floor fractures. Their study showed a sensitivity of 95% and a specificity of 100% with a diagnostic accuracy of 98%. Positive predictive value (PPV) reached 100% and negative predictive value (NPV) reached 77%. They recommended US as it is cost-effective, widely available and does not have the disadvantages of radiation exposure. US may also be used to show the disruption of the lens (Stassen and Kerawala, 2007)

It can be concluded that CT is a valuable tool in the management of blow-out fractures of the orbit, despite its limitations in detecting trapdoor fractures in paediatric blow out fractures. CT can provide information about the site, size of the fracture and the level of tissue involvement in the fracture defect. MRI has been also used, but to lesser extent, to assess more subtle orbital soft tissue injuries.

2.6. Investigations for ocular motility disturbances

Evaluation of diplopia with careful follow-up is invaluable in decision making for the management of blow-out fracture patients (1994). An initial clinical assessment may be performed using a linear light and requesting the patient to focus on and follow the light in the nine cardinal positions of gaze and report the presence of a double image (Stassen and Kerawala, 2007). Should diplopia be noted, referral for orthoptic assessment is indicated.

2.6.1. Clinical investigations (forced duction and forced generation test)

Forced generation and forced duction tests have been used to differentiate between an entrapped or paretic muscle. Topical anaesthesia is applied to the eye, and then an attempt is made to move the eye upward with toothed forceps, holding the conjunctival and episcleral tissue at the 6 o’clock limbal position. Difficulty in elevating the eye with the forceps indicates a positive forced duction test. This implies an entrapment of inferior rectus muscle and/or orbital contents within the fracture site.

While still holding the forceps, the patient is asked to look downward. The power of pull on the forceps will indicate if the inferior rectus muscle is intact or there is an injury with subsequent paresis (Putterman, 1991). Some surgeons prefer to do the test under general anaesthesia, suggesting that under local anaesthesia pain and muscle spasm may affect the result (Straker and Hill, 1989; Hartstein and Roper-Hall, 2000).

However, Straker and Hill (1989) believe that the forced duction test does not necessarily imply that the muscle itself is entrapped within the fracture, but it may be restricted by haematoma, tethering of orbital septa or fibrous adhesions. Rowe and Williams (1994) stated that negative forced duction test in the early post-traumatic period, does not exclude the possibility of herniation of tissue into the antrum since restrictive fibrosis may take 10 days to form.

2.6.2. Quantitative assessment of diplopia:

Early documentation and quantitative assessment of extraocular muscle function after the injury is of great importance as this will provide a tool for differential diagnosis, and aid in the decision regarding need and timing of surgical repair of the orbit, in addition to providing baseline data to assist in determining outcome (Hartstein and Roper-Hall, 2000).

Sokalska *et al* (2008) stressed on the importance of orthoptic examination in every patient with blow-out fracture before any surgical intervention, even with absence of diplopia. Absence of diplopia in some cases may be associated with preexisting binocular vision (BSV) problem and should be ruled out. A variety of orthoptic tests are available in the assessment of blow-out fractures, the more common being outlined below.

The binocular field of vision may be plotted on a Goldmann perimeter using standard charts. With both eyes opened, the patient observes a slowly moving target from the primary position. The patient is asked to state when the object appears double (Shotton *et al.*, 2008).

According to the concept of relative values, Esterman (1982) believes that certain areas of the field are functionally more important than others in human activity, the central part of the field being more valuable than the periphery, the lower hemisphere more useful than the upper, and the horizontal meridian more important than other meridia. Sullivan *et al* (1992) stated that diplopia score can easily be calculated from binocular single vision (BSV) score by the subtraction of the BSV score from 100 (weighted BSV score). They stressed on the importance of the fact that the score must be in the context of the patient's subjective complaints, systemic disability, and job requirements.

Kim and Woo (1999) in their postoperative follow up for 17 patients with blow-out fractures, found BSV scoring a reliable method for quantifying diplopia and monitoring improvement. Stocker *et al* (2005) recommended BSV tests should be done routinely for patients with orbital trauma. The recommendation of BSV over Hess Chart for routine evaluation of orbital trauma patients is based on the fact that it is a simple tool and allows numerical analysis for both orbital and visual functions (Stocker *et al.*, 2005; Stocker *et al.*, 2006; Banks, 2007).

Lee *et al* (2005) divided diplopia using un-weighted field of single binocular vision, into four levels of severity from zero to three; zero corresponding to no diplopia, one to mild (diplopia appears more than 30 degrees from the primary position), two to moderate (diplopia 10 to 30 degrees from primary position, three to severe (diplopia appears within 10 degrees from the primary position. Shotton *et al* (2008) examined the normal (weighted) range BSV field in normal population . They found that the score of 100% was rarely achieved by asymptomatic visually normal population, and the median normative BSV value was 94%. They also found that the BSV field is reduced with age.

Adams *et al* (2008) compared diplopia scores obtained with a diplopia questionnaire to the established Goldmann diplopia field. They found an acceptable agreement in the majority of patients. However, they suggested the diplopia questionnaire to be a better representation of the patient’s daily experience than the Goldmann diplopia field.

An alternative technique for diplopia assessment is cervical range of motion (CROM) (Holmes et al (2005). It is standardized in 9 gaze positions for distance fixation and 1 for reading, with score ranges from a minimum of 0-25. It has been described as valid, reliable, responsive measure of diplopia, easy to perform and requires minimal equipment (Holmes *et al.*, 2005). However, the presence of a strong magnet may prohibit its administration on patients with pacemakers.

2.6.3. Assessment of ocular motility defects

The Hess chart test is commonly used test for assessment of extraocular motility defects. The Hess chart gives a reproducible, record of ocular motility. It is obtained for each eye and usually the unaffected eye muscles show overaction in contrast to the contralateral affected muscle in the involved eye (Stassen and Kerawala, 2007).

Aylward *et al* (1992) suggested a new scoring system for Hess charts as they found the interpretation of Hess charts was subjective and comparison between charts may be difficult. Furuta *et al* (2006) used a Hess Area Ratio (HAR) measurement to express the ocular motility in numerical values by comparing the Hess chart between the affected and healthy side and they found that in patients with HAR more than 85%, most experienced no diplopia.

Uniocular field of fixation (UFOF) measurement of ocular motility has similarly been recommended for objective recording of eye movement. Unlike Hess charts, it provides a numerical score for the six extraocular muscles for each globe (Haggerty *et al.*, 2005). This test has been used in ocular motility assessment for Graves Ophthalmopathy[2] patients (Steel *et al.*, 1995; Gerling *et al.*, 1997; Haggerty *et al.*, 2005). However, its use has not been previously reported for orbital trauma patients.

The Double Maddox rod test is another ocular motility assessment technique. This test is particularly useful where superior or inferior oblique muscle weakness is suspected. It is objective, reliable, simple and cost effective method for evaluation of diplopia, and can be rapidly mastered (Shaunak *et al.*, 1995).

[2] Graves' ophthalmopathy is an autoimmune condition characterizes by marked orbital inflammation mainly affects the extra-ocular muscles and fibro-adipose tissue (Nikolousis 2011)

Folkestad *et al* (2007) demonstrated a new application of electro-oculography to identify the cause of diplopia in orbital floor fractures. By the use of the intact eye as the reference, any motility difference between the normal and injured eyes can be easily detected. The technique is based on electronystagmography equipment used for vestibular testing in daily ENT practice.

Galldiks and Haupt (2008) advised the use of electro-myography (EMG) in cases of blow-out fracture with incarceration of the EOM, as the diagnostic information derived from the EMG pattern may be helpful in decision making concerning surgical intervention and progress assessment.

Putterman (1991) mentioned the use of extraocular muscle motility assessment by the Urist light reflex technique and Turnbull *et al* (2007) considered intraocular pressure measurement for globe movement restriction, pressure increasing in the affected eye in upward gaze. He considered the equal measurements between both eyes (normal and injured as an indication of recovery of extraocular muscle impairment.

2.7. Management of blow-out fractures

2.7.1. General considerations

According to Manson and Iliff (1991) blow-out fractures have enjoyed “all” or “none” treatment policies, despite the fact that recent clinical studies and research provided some unifying concepts for evaluation and treatment. These concepts are based on better knowledge of orbital bone and soft tissue anatomy, physical examination, and the excellent definition of bone and soft tissue injury by thin slice CT scanning. They suggest that the surgical decisions involve two considerations: globe position (orbital volume) and diplopia.

Putterman (1991) mentioned the difficulty of making treatment decisions for “ the marginal group” of patients in which there is slow but steady resolution of diplopia with slight changes in enophthalmos. For this group he advises frequent measurement of extraocular muscle motility diplopia, enophthalmos, and hypo-ophthalmos. Rowe and Williams (1994) believed it is better to wait until oedema and swelling have subsided before coming to a definitive conclusion about the treatment. They suggested that whenever possible, a Hess chart should be completed prior to operation since this is the best way to obtain a base line for further assessment. Harris *et al* (1998) referred to the widely accepted protocol which states: if CT scan demonstrates a large blow-out fracture, enophthalmos is anticipated (even if it is initially masked by orbital oedema or haematoma), and surgery should be performed within 2 weeks of the injury. If CT scan demonstrates a small fracture that is unlikely to alter orbital volume, surgical decisions are based on ocular motility. In the absence of diplopia, small fractures are rarely repaired. In the presence of diplopia, examinations are repeated for up to 2 weeks, and surgery advised for patients whose symptoms remain clinically significant during this period. However, they stated that the ocular motility outcome according to this protocol has been less than ideal.

Dutton (1991) reasoned the controversy over the treatment of blow-out fractures by the absence of accurate evaluation of trauma patients: no quantitative criteria for diplopia or enophthalmos and an inability to predict the outcome of the treatment. Hartstein and Roper-Hall (2000) noticed that many of the ideas for the treatment of blow-out fractures derived from experience with more complex and comminuted facial fractures. Brady e*t al* (2001) stated that physician philosophy plays a major role beside the physical examination and radiographic interpretation in management of blow-out fractures.

Morris and Gill (2000), in their review of literature found many examples of early surgery with post-operative diplopia up to 50%, along with other examples of successful outcomes without diplopia in patients treated only with observation. Their policy of treatment was early surgery for those patients with disabling diplopia without demonstrable improvement in the first 2 weeks after injury, CT scan evidence of a fracture, or demonstration of muscle restriction by forced duction or Hess testing. Patients with trap-door type floor fractures and restriction would be operated on immediately. The authors also considered 2 to 3 mm of enophthalmos as an indication for surgery. On the other hand, patients with minimal symptoms, negative forced duction test, or reasonable ocular motility on Hess chart would be treated conservatively.

2.7.2. Conservative management

Koornneef (1982) believed that the repair of a pure blow-out fracture through placing of an implant may not address the real cause of the diplopia, which is he believed was due to disruption of the ligament system and septa. Furthermore, Manson and Iliff (1991) stated that surgery may not be necessary to correct diplopia, but it is frequently required for facial aesthetics.

Putterman (1991) believed that a significant proportion of patients can be managed conservatively, even with the entrapment of non-muscular orbital soft tissue. He explained the improvement of ocular motility disturbance following a blow-out fracture as a result of resolution of orbital fat oedema and haemorrhage with subsequent decreased tension on the orbital fat band with eventual stretch of orbital fat. He pointed out that some clinical tests such as the forced duction test can aid in differentiating an entrapped muscle from a paretic one, although they might be misleading and a positive result does not always correlate with entrapment. He recommended observation for patients with minimal and/or rapidly improving diplopia and good extraocular motility, supported by a negative forced duction test and positive or normal generation test. He also recommended conservative management for patients with CT scan evidence of extraocular muscle contusion (rounding) without entrapment and those patients without development of cosmetically unacceptable hypo-ophthalmos. Putterman did not think that all large blow-out fractures need to be repaired to prevent the development of enophthalmos; the author did not find a clear correlation between the size of the orbital fracture in CT scan and the amount of enophthalmos. He believed that the problem as to whether to perform surgery exists in those marginal cases with slow and slight resolution of diplopia or with slow development of a cosmetic deformity.

de Man *et al* (1991) preferred a ‘wait and see’ policy in the management of adult patients and recommended surgery only for patients with impairment in vertical motility within the “main field” after resolution of haemorrhage and oedema and stabilization of the eyeball position confirmed by Hertel exophthalmometer.

As Putterman (1991) preferred careful monitoring of diplopia and enophthalmos in the 2-3 weeks period of surgery, he advised the use of steroids to hasten the healing process, especially for patients with no evidence of extraocular muscle entrapment. A tapering protocol of systemic steroids for five to seven days was advised. Steroids would provide minimum improvement of diplopia if the motility restriction is secondary to true entrapment and that this information should help in the decision and timing of surgery.

The use of systemic steroids had been also been acknowledged by Millman *et al* (1987), with a steroid protocol consisting of 1 mg/kg of prednisolone. The authors similarly suggest that steroids hasten resolution of oedema in order to reveal patients with non-improving diplopia. In their study they found resolution of diplopia without surgery in patients with no CT evidence of entrapment or CT scan evidence of soft tissue prolapsed, in both steroid and non-steroidal anti-inflammatory groups resolution was noted within 5 days and enophthalmos unmasked within 1 week of treatment in the steroid treatment group. The study also suggested that they obtained improved surgical results with steroid treatment..

Nishida *et al* (2004) using Hess chart quantitative assessment of ocular motility, and binocular field of vision listed the following criteria for conservative management: orbital imaging without muscle entrapment; no strong mechanical restriction with forced duction test; an involved ocular motility range of more than 10 or 20 degrees, respectively, on the Hess chart at 15- or 30-degree movement of the fellow eye. If the patient meets these criteria, they suggested that ocular motility would most likely recover naturally.

Sleep *et al* (2007) stated that conservative management of isolated fractures of the orbital floor and medial wall is usually reserved for patients whose diplopia is resolving, who have minimal enophthalmos, and whose fractures are small and do not entrap the orbital contents.

The reason for the agreement about rapidly improving diplopia as a clinical guide for conservative management is the fact that it indicates that ocular restriction is mainly related to orbital haematoma and oedema rather than actual tissue involvement in the fracture defect. On the other hand, early clinical tests might not be reliable for enophthalmos management. The small size of fracture as shown in the CT scan is more reliable to consider conservative management with the absence of potential enophthalmos (Manson and Iliff, 1991).

To conclude, there are generally agreed criteria for conservative treatment. These are: minimum or rapidly improving diplopia, and/or minimal enophthalmos with no CT scan evidence of extraocular muscle entrapment.

2.7.3. Surgical management

The major bulk of literature about blow-out fracture has been directed towards surgical management, with a focus on criteria for surgical indication and surgical timing.

Dulley and Fells (1974) criteria for surgical intervention were: slowly resolving diplopia in the early days following injury; fracture with large tissue herniation; tissue incarceration in the fracture leading to globe retraction; and enophthalmos greater than 3mm. Straker and Hill (1989) recommended the criteria outlined by Dulley and Fells, with the addition to positive forced duction test.

Based on experience, Putterman (1991) listed the following indications for early surgery (within one to three weeks after trauma): patients with severe, visually handicapping, non-resolving diplopia with a positive forced duction test that does not allow upward movement of the eye, and with CT evidence of inferior rectus muscle entrapment, or in patients with severe cosmetically unacceptable enophthalmos or hypo-ophthalmos.

The indications for early surgery (within one to two weeks) as preferred by Dutton (1991) were: symptomatic diplopia with positive forced duction, showing no clinical improvement over one to two weeks; CT evidence of muscle entrapment; early enophthalmos of 3 mm or more; significant hypo-phthalmos; and a large orbital defect likely to result in late enophthalmos; or associated rim of facial fracture.

Rowe and Williams (1994) did not consider the CT scan findings in their criteria for surgical intervention: presence of diplopia, limitation of ocular movement with positive forced duction test, and tomographic evidence of the presence of a defect more than 0.5cm. Their objectives for orbital repair were: replacing the displaced orbital tissue, elimination of any interference with ocular movements, fracture reduction with restoration of orbito-antral partition and preservation of orbital volume and orbital fat.

Charteris *et al* (1993) stated the following indications for surgery: failure of improvement of the field of binocular single vision in serial orthoptic assessments (diplopia in the primary or down gaze position, for more than 6 weeks with no signs of significant improvement) presence of enophthalmos, especially during the early stage.

Bansagi and Meyer (2000) considered muscle entrapment resulting in ocular motility restriction with diplopia, early enophthalmos (more than 2mm), and orbital defects involving more than 50% of the floor or medial wall as a current generally accepted indications for surgical repair after an internal orbital fracture. Shantha et al (2000) also considered enophthalmos more than 2 mm in their indications for surgery.

Brady et al (2001) suggested that in US surgical practice the indications for surgical management were: diplopia in primary gaze or slight upward/downward gaze, enophthalmos 2 mm or more or substantial soft tissue herniation into the maxillary sinus if the fracture size is more than 50% of the floor area. With the increase number of orbital floor defect reconstructions, Ellis and Yinghui (2003) stated that it is still controversial on what basis the reconstruction should considered (eg, size, location, displacement, amount of soft tissue herniation, etc).

Burnstine (2003) mentioned non resolving oculocardiac reflex, in "white-eyed" blow-out fracture, and early enophthalmos or hypoglobus as indications for immediate surgical repair. He recommended surgical intervention within 2 weeks period in cases of symptomatic diplopia with positive forced ductions and evidence of orbital soft tissue entrapment on computed tomography examination or large orbital floor fractures, which may cause latent enophthalmos or hypo-ophthalmos. Koide *et al* (2003) stated that operative criteria in their surgical intervention on 200 patients with isolated fractures of the orbit included diplopia within 30 degrees and enophthalmos >3 mm. Lee *et al*.(2005) in a series of 45 patients listed the following indications for surgical intervention; enophthalmos more than 2 mm, persistent diplopia, positive forced duction test, and extraocular muscle entrapment.

Hamedani *et al* (2007) in their major review on enophthalmos, considered that cosmetic demand with or without diplopia is the main indication for surgery in enophthalmic patients, as enophthalmos appears in cases of larger fractures, which hardly have chance of muscular entrapment. They found 1-2 week(s) post injury to be the optimal period for surgery as it allowed for the resorption of orbital oedema and haemorrhage.

Turnbull, *et al* (2007) found that most surgeons agree that large fractures, enophthalmos and signs of entrapment are indications for surgery. Farwell *et al* (2007) considered the following criteria as indications for surgical intervention: restricted ocular motility with diplopia, clinically obvious enophthalmos, coronal CT scan (direct or reformatted from fine cut axial scan) showing evidence of fracture 2 cm^2 at least or 50% of the orbital floor associated with displaced orbital tissue and increase of orbital volume.

Parbhu *et al* (2008) divided the clinical indications for surgical intervention into adult and paediatric groups. Their figures showed that entrapment represents the highest number of surgical indications for paediatric blow-out fractures, compared with enophthalmos and large fractures which represent the lowest number. Enophthalmos, conversely, had the highest number of surgical indications in adult age group.

Although uncommon, progressive infraorbital paraesthesia has been suggested as one of the surgical indications for blow-out fractures of the orbit. Boush and Lemke (1994) reported 2 cases of severe, progressive infraorbital nerve hyperaesthesia which required surgical intervention. They believe that progressive infraorbital nerve hyperaesthesia should be considered a primary indication for blow-out fracture repair in selected patients in whom hyperaesthesia is both severe and progressive. Persistent hyperaesthesia of the infra-orbital nerve is another indication for exploration of the orbital floor following blunt orbital trauma; Tengtrisorn *et al* (2007) reported 2 cases of persistent and severe hyperaesthesia in the distribution of the infra-orbital nerve 12 and 26 months, respectively, after blunt orbital trauma.

Surgical timing for blow-out fracture cases and its influence on both postoperative diplopia and enophthalmos has been debated in the literature. Dulley and Fells (1974) believed that the optimum time for surgical repair, if indicated, to be within 10-14 days. By this time orbital oedema and haematoma will have settled to permit examination of ocular motility and orbital tissue fibrosis will not have occurred. They found that cases treated within 14 days had 80% as average of BSV score.

Hawes and Dortzbach (1983) also advocate early repair (within 2 weeks of the injury) on fractures with CT scan evidence of more half of the floor missing which would result in more significant enophthalmos even in the absence of clinical enophthalmos, as well as patients with persistent extraocular muscle dysfunction.

Manson and Iliff (1991) suggested that the optimal time to reconstruct orbital injuries requiring surgical treatment is as soon as possible following injury, when other considerations permit. They mentioned that early release of CT documented incarceration of the musculo-fibrous ligament system is beneficial on functional grounds for patient with diplopia and positive forced duction, especially with tight or moderate incarceration of muscle or adjacent fat in the orbital defect, to allow healing in a correct anatomical position. They believed that early bony restoration will help in proper replacement of the displaced fat. Furthermore, late surgery not only has no effect on preservation of the soft tissue, but, also there will be shortening of the traumatized muscle after posterior globe displacement and it seldom produces results which are aesthetically comparable to those obtained by early definitive repair.

Smith *et al* (1998) advised the release of entrapped orbital tissue within 24 to 48 hours of injury to avoid permanent muscle damage. Furthermore, they stated that early enophthalmos will worsen when oedema resolves and fibrosis begins.

Courtney *et al* (2000) sent a questionnaire to 256 practicing fellows of the British Association of Oral and Maxillofacial Surgery. They found that over half the respondents preferred to operate 6–10 days after the injury. Brady et al (2001) mentioned 1-3 weeks as a period for early surgery as a protocol in USA. Hosal & Beatty (2002) suggested that surgical repair of blow-out fractures within two weeks of trauma decreases the incidence of residual diplopia.

Haddad (2003) stated that if a blow-out fracture with muscle entrapment is not treated within 10 days of the trauma, this will result in fibrosis of the involved muscle and permanent functional disability. Therefore, he stressed the need for surgical intervention within 9 days; otherwise subsequent strabismus surgery might be necessary. This agrees with Rowe & Williams (1994) suggestion of 10 days period as critical for extraocular muscle fibrosis to take place. Ogata *et al* (2004) reported their treatment for 4 children under 10 years old with strangulated trapdoor blow-out fracture. Their cases showed that favorable results when surgery was performed even after 2 weeks.

Jaquiery *et al* (2007) found that best functional and cosmetic results were be achieved by early revision and repair. Kuttenberger *et al* (2008) in their series of 70 patients concluded that the best functional outcome after orbital floor surgery is achieved if surgical treatment was performed within one week post trauma. Brucoli *et al* (2011) also supported early surgical intervention for blow-out fractures. In their retrospective study on 75 blow-out fractures patients they found that patients who had surgery within 2 weeks post injury had lower risk of postoperative diplopia.

With regard to paediatric patients, Sires *et al* (1998) advocated immediate coronal CT scanning for paediatric patients experiencing bradycardia, nausea, and syncope following orbital injury. If a trapdoor fracture with incarceration of soft tissue is identified, the fracture should be repaired the same day. They stated that fracture reduction and release of the muscle and/or connective tissue will not only protect the patient from life-threatening cardiac arrhythmias but also ischemic necrosis of the muscle with subsequent fibrosis and permanent diplopia. Jordan *et al* (1998) found that 2 week waiting period policy for such white-eye blow-out fractures may result in poor motility outcome and advocate surgical intervention within a few days post trauma to avoid permanent diplopia.

Smith *et al* (1998) stated that paediatric fractures in general should be treated within the first week because of the more rapid healing process in children. Several authors supported early surgical intervention for children and young adults with trap-door fractures with severe entrapment and non-resolving oculocardiac reflex (Bansagi and Meyer, 2000; Egbert *et al.*, 2000; Kwon *et al.*, 2005), because of the strangulation of periorbital soft tissues within the trapdoor type of blow-out fractures, which is more common in children, surgical intervention should be performed as soon as possible (2007). Humphrey and Kriet (2008) pointed out that immediate intervention in the treatment of orbital floor fractures is indicated only when orbital soft-tissue entrapment is associated with the oculocardiac reflex.

Kwon *et al* (2005) in their study comparing blow-out fractures in children and adults found among the 13 children with trapdoor fractures, the recovery period was significantly shorter in those who underwent surgery 1 to 5 days after the trauma, compared to those who underwent surgery 6 - 14 days and 15 days or longer. In adults the recovery period in those who underwent surgery 1 to 5 days and 6 to 14 days after the trauma were significantly shorter compared with those who underwent surgery after 15 days. Kakizaki *et al* (2007) found that good results could be achieved in cases of orbital trapdoor fractures with muscle incarceration when they are urgently operated on. They explained the need for urgent surgery by the fact that extraocular muscles require good blood supply; hence they will suffer severe ischemia and subsequent necrosis if they are trapped, especially with the attempts of ocular movement.

Parbhu *et al* (2008) agree with the findings of previous authors that younger patients with trapdoor fractures with soft tissue entrapment require more immediate repair, in contrast with older patients with open door fractures. They found a significant difference between the timing of surgical intervention in the paediatric patient in comparison to the adult patient with an orbital floor fracture. They also found that the most common clinical indication for surgery was entrapment in the paediatric group versus enophthalmos in the adult group.

In conclusion, there is a fairly general agreement about the management of blow-out fractures in terms of surgical indications. These indications are: cases of large orbital floor fractures and/or extraocular muscle involvement with positive forced duction test. In addition, most studies recommend surgical intervention within 2 weeks. In cases with orbital muscle entrapment and paediatric blow-out fracture, it is not agreed how early the intervention should take place, although where an occulocardiac reflex is apparent this would indicate immediate surgery.

Orbital Surgical approach

Orbital approaches are the most widely used approaches for the treatment of blow-out fractures. They are considered safe and efficient approaches in accessing the fractures, and allow reconstruction of the orbital floor without difficulty and with predictable results (Humphrey and J. David Kriet, 2008).

- Trans-conjunctival approach:

The trans-conjunctival technique was originally described by Bourguet (1928), for the treatment of fat herniation in the lower eyelids, and developed by Converse *et al*, (1973), and Tessier, (1973), for the treatment of orbital fractures. It has the obvious advantage of an invisible scar but also the disadvantage of restricted access and limited extension. It also requires a greater degree of operative skill. It is most useful for those procedures which do not require an extensive exposure of the orbit and fractures limited to the inferior margin and anterior aspect of the floor (Rowe and Williams, 1994).

An additional advantage of this approach is decreased risk of ectropion when compared with the subciliary approach (2000). The theoretical advantage of the postseptal technique over preseptal approach, is a decreased incidence of postoperative lower lid malposition since the plane between the orbicularis oculi and orbital septum is not violated (Riu *et al.*, 2008), although the continually protruding periorbital fat can be an annoyance.

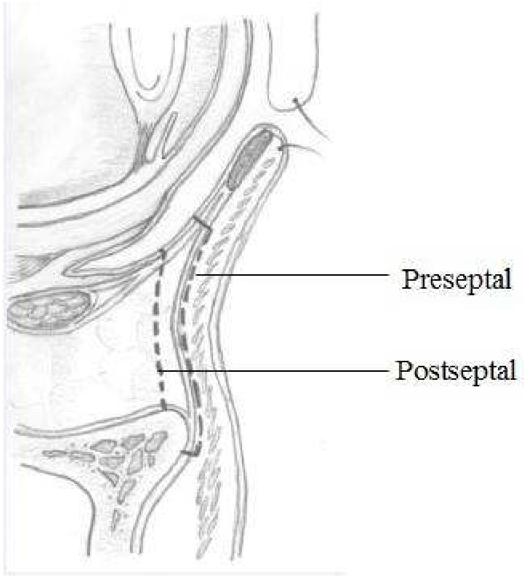


Figure 2-4 Pre- and postseptal variations of the transconjunctival approach (adaped from Humphrey & Kriet 2008).

Baumann and Ewers (2001) preferred the preseptal transconjunctival approach to the postseptal transconjunctival approach (Figure 2-4) as the latter results in additional disturbance of the intraorbital connective tissue framework. Such disturbance could result in scarring of the fibrous septa involved in eye movement, participating in the development of enophthalmos, and risk of fibrosis and vertical shortening of the tarsal plate. They pointed out that the preseptal transconjunctival incision without lateral canthotomy provides good exposure of the orbital floor and the caudal parts of the lateral and the medial wall.

Novelli *et al* (2008) considered the transconjunctival approach as simple surgical with good functional and aesthetic results. They think that it is the best choice for orbital floor and medial orbital wall fractures, as it avoids interference with the lacrimal drainage system and gives a wide visualization of the orbital floor compared with the palpebral approach. Some surgeons combined this approach with endoscopy for better visualization of orbital regions, while others have combined it with transcarnucular approach for medial orbital wall surgery (Kushner, 2006).

- The subciliary/subtarsal approach:

The subciliary/subtarsal approach was originally described by Converse (1944) with a preference for the subtarsal technique (Figure 2-5). Both transcutaneous approaches provide access to most of the orbital floor (Baumann and Ewers, 2001). The cutaneous approach provides an excellent exposure of the entire orbital floor and the lower part of the lateral and the medial walls. If combined with other approaches from the outer or inner aspects of the eyebrow, almost all areas can be reached with safety and without difficulty, also it is better for major displacements of the floor, or when the exact extent of the injury cannot be accurately assessed beforehand (Rowe and Williams, 1994). Smith *et al* (1998) also advised this approach for the wide surgical exposure required for extensive orbital reconstruction.

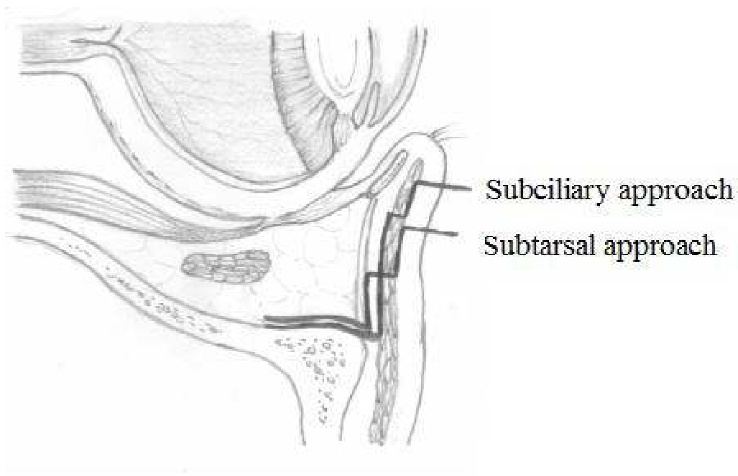


Figure 2-5 Paths traversed by the subciliary and subtarsal approaches through the lower eyelid (adapted from Humphrey & Kriet 2008)

Advantages of the subciliary and subtarsal approaches are that they are easy to learn and offer broad access to the orbital floor. Disadvantages are greater rates of postoperative lower lid malposition and visible scarring when compared with the transconjunctival approach. As such, technique in the transcutaneous lower lid approach must be flawless to minimize the risk of scleral show and ectropion.

Rohrich *et al* (2003) argued that the subtarsal variation of this approach produces less risk of vertical lid shortening, scleral show and ectropion but slightly greater risk of visible scarring. Innervation to the pretarsal and much of the preseptal orbicularis is better preserved through the subtarsal variant which may help maintain the preoperative lower lid position (Baumann and Ewers (2001). Baqain *et al* (2008) referred to the safety and simplicity of subtarsal approach as it is used in orbital floor fractures with good functional and aesthetic surgical outcome.

Comparison between transconjunctival and subciliary approach has been a centre of debate for several articles among most of which favoured the transconjunctival approach, because of lower incidence of ectropion and/or lid position problem. Maxillofacial literature has also shown a trend toward this approach, providng necessary access for surgical treatment with better cosmetic results (Kushner, 2006). However, some surgeons have advocated transcutaneous approaches for the medial orbit exposure (Kushner, 2006). Kolk *et al* (2008) in their retrospective/prospective study on 185 patients with various orbital fractures showed that large fractures of the orbital floor or its posterior portion as well as combined fractures should be treated via an open approach as they have better long term outcomes, while the transconjunctival access is sufficient for small trapdoor fractures or that of the anterior part of the orbit.

Riu *et al*.(2008) in a retrospective study compared the outcomes of two different approaches to the orbital floor: the classic subciliary versus the transconjunctival plus lateral canthotomy (swinging eyelid). Forty-five patients who underwent orbital surgery (47 approaches) for different indications were placed in two groups, depending on the approach. Their findings showed the advantages of the swinging eyelid: better aesthetic results, the same or greater exposure of the orbital floor and the caudal part of the lateral and medial walls, shorter surgical time (sutureless) and a less extensive scar. Although in their experience this approach is preferable in orbital surgery, some indications for the subciliary still remain, such as pre-existing bone-exposing eyelid lacerations, a high risk of a corneal or globus lesion (i.e., hyphaema), hypertrophic orbicularis muscle, the need to remove eyelid fat, the need for skin resection, conjunctival pathology and ophthalmic prosthesis.

Maturo and Lopez (2008) reported that the transconjunctival approach with canthotomy and cantholysis provided exceptional exposure to the inferior orbital rim, the orbital floor, and the lateral orbital wall. Although canthotomy and cantholysis are not a requirement, they have found that exposure is significantly enhanced when lower eyelid tension is minimized.

- Transcaruncular approach

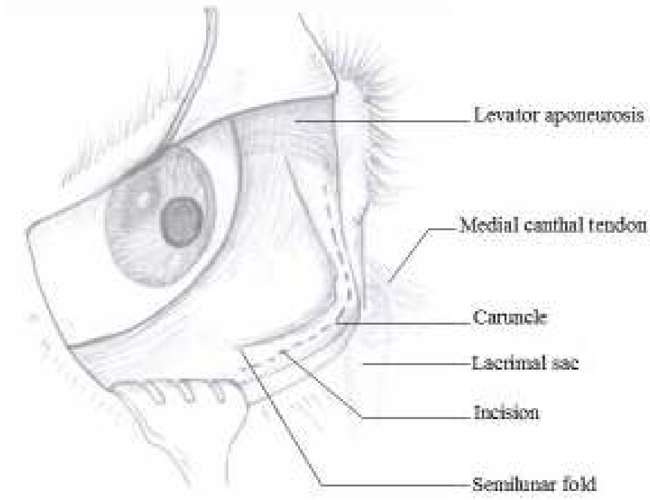


Figure 2-6 transcaruncular approach; reproduced from Humphrey & Kriet 2008

Garcia *et al* (1998) presented an approach to medial orbit via an incision through the caruncle, combined with an incision along the inferior conjunctival fornix. This approach provides wide exposure for fractures involve the medial and inferior orbital walls. They suggest that the transcaruncular approach is suitable for surgical repair of medial wall blow-out fractures together with an inferior transconjunctival incision.

Shorr *et al* (2000) used a combined transfornix-transcaruncular approach in 19 of 24 orbits. They found no complications related to either approaches, with fracture reduction carried out safely, and deemed this a suitable substitute for medial cutaneous incision (Lynch approach) for medial orbital wall.

Moe (2003) in a cadaver and clinical study advocated the use of a precaruncular approach for the medial orbital wall. He found it superior to transcaruncular because of reduction in oedema and irritation of the surgical site associated with the latter. He reasoned these complications were due to the complexitiy of the caruncular epithelium. Also he believed that the precaruncular approach was less time consuming and presented a bloodless surgical field. Edgin *et al* (2007) recommend the transcaruncular approach, arguing that the Moe approach needed further clinical evaluation.

- Transantral approach

Rowe and Williams (1994) stated that a decision as to whether to open the antrum or whether to proceed directly to an exploration of the orbital floor depends upon the judgment, based upon experience, of the surgeon in the light of all the evidence available. If the surgeon is in doubt, they advised initial exploration of the antrum due to ease, with subsequent exploration the orbital cavity in the same operation if required. They advocate antral support for the orbital floor when there was a communication and the fracture segment is attached to the periosteum or antral mucosa or in case of trapdoor fractures. An *et al* (2005) in a 4 year retrospective study found that transantral reduction of orbital floor using a foley catheter showed favourable functional and aesthetic results. They believe that it is a reliable method for the treatment of orbital blow-out fractures.

Conversely, Hartstein and Roper-Hall (2000) reported that this approach may cause residual enophthalmos after fracture repair, because of inadequate surgical exposure. However, they agreed with Rowe and Williams' advice in the use of an endoscope through maxillary antrostomy for better visualization of the posterior margin of the defect and to ensure complete removal and proper repositioning of the orbital contents. Furthermore, Sleep *et al* (2007) think that antral packs have little place in the management of orbital injuries as they correlate with inadequacy of restoration of the orbital skeleton and the incidence of persistent diplopia. This agrees with the emphasis of Hammer and Prein (1995) on the importance of adequate reconstruction of the orbital skeleton because of the higher incidence of diplopia in patients with severe enophthalmos.

Endoscopic approach alone or combined with orbital approach has been advocated by some authors. Strong *et al* (2004) used transmaxillary endoscopic approach on 16 cadavers and 10 clinical blow-out fractures cases. They concluded that the endoscopic transmaxillary approach is a safe, technique and offers improved visualization, with no risk of postoperative eyelid complications, and good clinical results.

Farwell *et al* (2007) stated that the transantral endoscopic approach can be used successfully in patients with diplopia caused by entrapment of periorbital tissue within small fractures, as the safety of the procedure can save the time usually spent on investigation to confirm the entrapment. This technique is also useful as an adjunct to the orbital approach in cases when difficulties might be faced in establishing the posterior bony margin. Kim *et al* (2008a) confirmed that endoscopically-assisted intra-oral, trans-antral approach in combination with the extra-oral approach is a very valuable method in visualizing the posterior extent of the fracture, as well as to assist in reduction of a comminuted fracture of the orbital floor.

In order to describe the best way to apply the endoscopic approach, blow-out fractures have been divided on anatomical basis into: (1) trapdoor, (2) medial blow-out, and (3) lateral blow-out fractures. Trapdoor fractures occur when the fractured fragment (medial to infraorbital groove) remains "hinged" and this type is the most amenable to endoscopic repair; medial blow-out refers to complete displacement of the bony fragment medial to infraorbital groove; lateral fracture involves both medial and lateral aspect of orbital floor. This type is not amenable to the endoscopic approach (Strong, 2004; Strong, 2006).

Park and Diaz (2008) suggested a transantral microscopic assisted repair of the paediatric orbital floor fracture. They believe this technique provides excellent visualization of the entire orbital floor defect and facilitates placement of a polyethylene implant.

- Transnasal approach

Ikeda *et al* (1999) did a retrospective analysis of 11 patients who underwent surgical repair of orbital floor fractures using an endonasal approach. They stated that this approach is a safe and effective technique for the treatment of diplopia. The endoscopic approach enables meticulous manipulation of the repair, as it provides better visualization of the fractured structures of the orbital floor, reducing both intraoperative and postoperative complications. Rhee and Chen (2006) described a transnasal approach for medial orbital defects, either alone or with a transcaruncular or transconjunctival approach to facilitate precise placement of an implant for medial orbital wall reconstruction. According to Humphrey and Kriet (2008) this approach has the advantage of adequate visualization of the bony defect and limited risk to intraorbital structures, especially if the operator is experienced with intranasal endoscopic approach. The disadvantages of this approach are the increased risk of skull base injury with CSF leak and limited space for implant introduction.

Despite the fact that the endoscopic approach provides better visualisation for posterior fracture defects, difficulties might be encountered during implant insertion. Technical difficulties which might hamper implant insertion in some cases might limit the use of this approach alone. Consequently, the use of combined endoscopic and orbital approaches might be recommended (Farwell *et al.*, 2007). Kwon *et al* (2008) reviewed medical records of 102 patients with pure inferior blow-out fractures whom were treated by transorbital, transantral and combined approaches. Based on patients' post-surgical ocular symptoms, they suggested that patients with large orbital floor fractures or posterior half fractures should be treated using a transantral or a combined approach, while patients with trapdoor fractures or anterior half fractures of the orbit are better treated with transorbital or a combined approach.

Materials used for reconstruction of the orbital floor

Implant material for repair of the orbital floor need to performe the following functions: to seal off the antrum from orbit, to provide both a physiological and physical surface to avoid adhesions, to restore the orbital contour and dimension and to give indirect support to the eyeball (Rowe and Williams, 1994). Potter and Ellis (2004) stated that ideal implant material should have three main characteristics: it should replicate the missing tissue; should be easy to handle and should be bio-inert and bio-compatible.

Regardless the choice of implant material, Manson and Iliff (1991) stressed the importance of complete dissection of the orbital floor to demonstrate the entire defect and the intact normally positioned bone surrounding all edges of the fracture. Furthermore, the unique anatomy of the orbit, which dictates the choice of approach needed, has its influence on the type of the implant material to be inserted to replace the defect (Kozakiewicz *et al.*, 2008). Ellis and Messo (2004) in their review on orbital implant material, further specified that the choice for primary orbital reconstruction for acute orbital injuries might differ from the choice of material used for cases of established enophthalmos or hypoglobus. In the chronic cases there could be a change of soft tissue configuration from pyramidal to spherical. This means that the required material should recreate the normal internal anatomy of the orbit.

Courtney *et al* (2000) stated that the choice of implant material for orbital wall reconstruction, either alloplastic or autogenous, is governed by the clinical circumstances and surgeon preference. However, both materials have their advantages and disadvantages, which make the selection for suitable implant material for orbital repair a controversial issue (Uygur *et al.*, 2009; Prowse *et al.*, 2010).

Autogenous bone graft for most surgeons is the gold standard material for bone tissue repair (Baino, 2011). It has been the material of choice for about 40 years (Lee *et al.*, 1998). The recommendation for the use bone graft as an implant material based on the fact that it has less risk of infection and low extrusion rate.

There is a particular preference for cranial bone graft because of lower donor site morbidity, and less resorption/ more dimensionally stability, being a membraneous bone (Zhu *et al.*, 2001). However, Sleep *et al* (2007) believe that an iliac corticocancellous bone graft is ideal for orbital construction. Even with the loss of up to 30% of the thickness of these grafts, the remaining thickness of the grafts closely matches the thickness of the intact orbital floor. The authors pointed out that there is no evidence to support that one biomaterial is superior to another in relation to orbital tissue reaction.

In addition to split calvarial grafts, iliac crest bone grafts are currently considered to be suitable bone graft material (Baino, 2011). One other suggested donor site is the anterior wall of maxillary sinus (Mandel, 1975; Lee *et al.*, 1998). The advantages of this choice is that it obviates the need for two team approach as used in rib or iliac crest grafts, less operation time and there are no external incisions. However, it has the disadvantage of limited size which limits its use to small defects (Lee *et al.*, 1998; Morong *et al.*, 2010).

Autogenous bone graft, however, has its complications: donor site morbidity; resorption with potential enophthalmos and difficulty of contouring (Morrison *et al.*, 1995; Gear *et al.*, 2002). These drawbacks have led many surgeons to use alloplastic materials (Manson *et al.*, 2002). In addition, donor site morbidity makes such bone grafts unsuitable choice for small isolated orbital fractures with minimal possibility of enophthalmos (Fries, 1994).

Autogenous cartilage grafts have been advocated recently by some researchers. The advantages of autogenous cartilage grafts are that they are easier to harvest and manipulate. They provide long term support as cartilage does not undergo resorption for some considerable time (Baino, 2011). Talesh *et al* (2009) advocated the use of nasoseptal cartilage as the material of choice in the repair of orbital floor as an easily accessible, available autogenous source with minimal donor site morbidity. Also it is extremely adaptable to the orbital walls. The authors advised the use of 2 layers of nasoseptal graft in large defects. They stress the superiority of nasoseptal graft over alloplastic implant, homografts and bone grafts on the basis of cost, displacement, possibility of infection, operation time and postoperative complications. Castellani *et al* (2002) recommended the use of the auricular conchal grafts for small orbital floor defects, being easy to harvest and providing good support/ adequate stability, with minimum donor-site morbidity.

Courtney *et al* (2000) in a questionnaire study of 256 practising Fellows of the British Association of Oral and Maxillofacial Surgery found 66% per cent of respondents preferred Silastic as an implant material. Autogenous bone and cartilage was used by 56%, with calvarial bone recommended by 28% of the respondents, while titanium mesh was preferred by 18%.

Silastic is a widely used implant material because of its low cost, availability, easy shaping and adequate rigidity, Fries (1994). Potter and Ellis (2004) stated that silastic material's resistance to phagocytosis by immune cells would enhance fibrous tissue capsule formation around it. This capsule makes it tolerable by the body and once stable the long term existence of the material would be unproblematic.

Another widely recommended material is porous ultra-high density polyethylene ('Medpor'®). This material has been used successfully for about 20 years in the surgical repair of orbital defects (Baino, 2011). Romano *et al* (1993) recommend the use of Medpor® as it was a biocompatible and adaptable material with long-term stability. It has good resistance to stress and the presence of pores facilitate vascular in-growth, decreasing the chance of infection. Morris and Gill (2000) also found Medpor® implants satisfactory as their smooth surface when placed under the orbital tissue decreases scar tissue formation, can be shaped to fit , and the presence of channels makes it easy to use with titanium miniplates. Hosal and Beatty (2002) in a series of 42 patients used Medpore® as their first choice material for reconstruction of orbital floor defects in blow out fractures.

Marasco *et al* (2005) in their analysis on 268 patients with orbital floor fractures, reported orbital floor reconstruction by autogenous bone graft, titanium mesh, Medpor® and lactosorb implant systems. They concluded alloplastic materials are a suitable substitute for autogenous bone grafts if the latter is contraindicated or by surgeon preference. Furthermore, Theologie-Lygidakis *et al* (2007) in their series of 16 paediatric and adolescent patients used soft dura substitute and thin polyethylene sheet . They found that the use of an alloplastic implant material on top of the fracture lines after soft tissue release ensured adequate support with no re-entrapment.

Han and Chi (2011) reviewed the medical records of 331 blow-out fractures' patients. 106 patients had surgical repair with Macropore and 225 patients were treated with Medpor®. They found that both materials provided a satisfactory outcome and there was no significant difference between the two materials in term of ocular motility and enophthalmos.

Absorbable polymers have also been used over the last three decades. These materials are easily shaped to the defect, well tolerated and offer more predictable absorption compared with biological grafts (Baino, 2011). Enislidis et al (1997) advocated the use of biodegradable lactosorb implant materials with resorbable screws for sizeable orbital floor defects to avoid donor site morbidity and the need for removal. Jank et al (2003) reviewed 435 patients with an orbital fracture reconstructed by lyophilized dura-patches, polydioxanone (PDS) foils, and Ethisorb® biodegradable material. They recommend Ethisorb® because of its low complication rate.

Büchel *et al* (2005) used Ethisorb® synthetic resorbable patches, which was originally designed to bridge dura mater defects, for orbital floor reconstruction. The results of their study demonstrated the effectiveness of Ethisorb® in the repair of small to moderate size orbital defects.

Al-Sukhun and Lindqvist (2006) compared their clinical findings on the use of autogenous bone grafts and bioresorbable poly-L/DL-Lactide implants to repair inferior orbital wall defects. They concluded that there is no disadvantage in bridging orbital defects using biodegradable materials.

Kruschewsky Lde *et al* (2011) compared auricular cartilage graft and absorbable polyacid copolymer in 20 patients with blow-out fractures of the orbit. They found no difference between the two materials in term of both functional and aesthetic outcome.

Metal, titanium mesh in particular has also been widely used for orbital floor defect repair. This material is highly biocompatible, with osteo-integration and mechanical properties which make it a suitable substitute for bone (Baino, 2011). Ellis and Tan (2003) found both bone and titanium mesh can be successfully used to reconstruct isolated blow-out fractures of the orbit. Furthermore, irrespective of the material used in reconstruction, the soft tissues of the orbit were adequately replaced. However, they suggested that titanium mesh is more suitable for posterior defects.

Schon *et al* (2006) reported pre-operatively preformed titanium mesh implants, based on 3D CT models, to be more precise, less invasive and less time consuming compared to 'free hand' formed titanium mesh or calvarial grafts. The authors stated that this technique precisely predicted the required reconstruction for complex orbital defects involving more than one orbital wall. Kozakiewicz *et al* (2008) also reported the clinical application of three dimensional, pre-bent titanium mesh for orbital floor fracture surgery. They stated that the technique was financially viable and clinically practical.

Disadvantages of titanium implants include possible 'edge abrasion' upon shaping of the metal to suit the defect, and late complications such as infection, metal corrosion and toxicity. To overcome some of these problems a new titanium mesh, covered on both sides by a thin sheet of polyethylene material, has been recently introduced (Baino, 2011).

Size of the fracture defect and volume loss might influence the choice between single or 2 implant materials. Jaquiery *et al* (2007) advised the use of single implant material in small to medium size defects, and a combination of different materials in large orbital defects. Lieger *et al*. (2010) suggested the use of calvarial bone graft combined with a wedge of irradiated homologous costal cartilage placed behind the globe to repair post-traumatic enophthalmos.

Despite the choice of materials available for orbital floor defect reconstruction, there appears to be a tendency toward the use of titanium mesh and porous Medpor® in orbital wall reconstruction Ellis and Messo (2004), Potter and Ellis (2004) and (2006). Nevertheless, the choice of the implant material is still highly dependent on operator's preference. This might be explained by the interaction between the factors that influence the choice, which are the advantages and disadvantages of each material, and the nature, the shape and the size of the defect and expected complication in each particular case.

2.7.4. Late management

According to Putterman (1991), extraocular muscle motility in orbital floor fractures rarely improves beyond 5 weeks post-trauma. As such, Putterman advocated muscle surgery to treat late diplopia in these cases. In addition, he believed that surgery even after 3 weeks will result in little improvement. Fan *et al* (2003) reported late surgical treatment, one month to two years post-injury, for orbital blow-out fractures in 42 patients with enophthalmos. The authors found that enophthalmos was corrected in 32 of 42 cases and improved in the remaining 10 patients. Twenty-five of the 42 patients also presented with preoperative diplopia, which was corrected in 5 patients and improved in 10 patients postoperatively. The remaining 10 patients had no significant change to their diplopia. Preoperatively 19 of 42 patients had restricted motility with recovery in 7 cases, improved in 4 cases and no change in 8 cases post-operatively.

Hinohira *et al* (2008) performed endonasal endoscopic surgery for 6 patients 3 months post-trauma. The authors suggested that adhesion between the periorbita, bone fragments and sinus mucosa is the main cause for disturbance of ocular motility disturbance, and recorded disappearance of diplopia in 5 of their cases. They concluded that mechanical motility disturbances could be treated in delayed cases.

Although some researchers stated that diplopia could be improved with late surgical intervention, this does not provide decisive evidence to support the delay of surgical intervention. However, it seems that there is no clear evidence about the period between the 2 weeks and 4 weeks post-trauma and how outcome following surgical intervention within this period could be different.

2.8. Postoperative diplopia

Persistent postoperative diplopia is a frequent problem following the surgical management of a blow-out fracture of the orbital floor, even when repaired within 15 days of the trauma. There is no general consensus about the most likely cause. Some authors have attributed the cause of postoperative diplopia to myogenic or neurogenic causes. Harley (1975) suggested that incarceration of inferior rectus and inferior oblique muscles for long periods worsens the postoperative prognosis. Hollier and Thornton (2002) suggested inadequate surgical release of incarceration, recurrence of incarceration or adhesions to the reconstructive material as causes for postoperative diplopia.

Antonyshyn *et al* (1989) evaluated the results of complex reconstructions in 49 severe orbital fractures, and reported that 12% of patients had residual strabismus and 10% had enophthalmos. Biesman *et al* (1996) recorded 20 of 54 patients (37%) with postoperative diplopia. 17 out of 54 cases (31%) reported with both medial wall and floor fractures. The authors found that patients with combined orbital floor and medial wall fractures appear to be at higher risk of clinically significant diplopia postoperatively than those with fractures of the orbital floor only. They explain this difference by the difficulty in restoring the preoperative orbital contours in combined fractures. Meyer *et al* (1998) in a two year postoperative follow up found that 91% of the patients (242) with several types of orbital floor fractures, demonstrated that the degree of postoperative enophthalmos was related to the quality of bony reconstruction, rather than the extent of the initial bony defect.

Cope *et al* (1999) reported that long-term outcome in children with blow-out fractures is worse than that in adults with similar injuries. In their study on 45 children (up to 15 years old) they divided the children to 3 age groups: 0-9 years (9) patients, 10-12 years (11) patients and 13-15 years old (25) patients. They found that more than half the 0-9-year-group had persistent diplopia compared with less than a third of the two other 2 groups. Hosal and Beatty (2002) in their study on 42 patients with blow-out fractures, found that the age of the patient and timing of surgery were significant for the development of post-operative diplopia; elderly patients were more liable to develop postoperative diplopia and early surgical repair (within 2 weeks of the trauma) decreased the chance of residual diplopia. They found that sex, location of the fracture (orbital floor or combination of orbital floor and medial orbital wall) and the type of the alloplastic material used were not significant in relation to the development of residual diplopia.

Kim *et al* (2003) in their retrospective study of 76 patients with blow-out fractures agreed that patient age and timing of surgery were significant factors in development of postoperative diplopia, and the type of alloplastic material was not a significant factor. Nevertheless, they found fracture location and fracture size were also significant. Furthermore, they found timing of surgery and fracture size were significant in the development of postoperative enophthalmos, but patient age, fracture location and alloplast material were not significant.

Koide *et al* (2003), in a series of 200 patients with isolated orbital fractures, found that the highest success rate for complete resolution of diplopia was observed when surgery was performed within 3 days of the injury. Furthermore, enophthalmos was improved to less than 2 mm postoperatively for patients who had surgery within 14 days.

Sawano *et al* (2005) tried to correlate the postoperative surgical result with the type of surgery in sixteen cases of blow-out fractures. They found that the recovery from diplopia was excellent in patients with trap door type and bone defect type fractures, however, recovery was less in the muscle caught (entrapped) type after surgery. Lee *et al* (2005) in their analysis for 45 patients various orbital wall fractures found that postoperative ocular motility disturbances were more common in patients who presented with initial severe extraocular motility disturbance after trauma.

Criden and Ellis (2007) reported delayed recovery of extraocular muscle motility, even for months, in their series of 12 children with linear fractures with muscle entrapment. Sleep *et al* (2007) in their study on 6 patients with blow-out fractures of the orbital floor found that the mean time for the resolution of diplopia after reconstruction was 4.4 months, ranging from 1-7 months. They suggested that: young patients, elderly patients, patients whom were operated on after 2 weeks, and patients with temporary antral packing had a high risk for development of post-operative diplopia. Moreover, they agreed with Biesman et al, 1996, regarding the high possibility of diplopia in patients with extensive fractures of deep orbital floor, posterior to the anterior limit of the inferior orbital fissure.

Jaquiery *et al* (2007) in their series of 72 patients with various orbital wall fracture reconstructions, found that 91% of the patients had no diplopia within 20 degrees and that the best postoperative results for motility could be achieved with early surgical intervention. Kuttenberger *et al* (2008) in a 3 month follow up of 70 blow-out fracture patients who underwent surgery, recorded normal ocular motility in 46% of the patients, 51% showed an improvement and 3% no change.

There would appear to be general agreement in the literature about the high incidence of postoperative diplopia in blow-out fractures of the orbit. Direct soft tissue injury has been shown to be one of the factors involved. Some researchers have suggested postoperative diplopia is the result of late surgical interventions, and others have argued that inadequate surgical manipulation and repair is a cause. Multiple orbital wall involvement has been also found to play a role in postoperative ocular motility defect. However, it is agreed that persistent diplopia could be corrected by strabismus surgery. Harley (1975) reported the elimination of persistent diplopia in association with blow-out fractures of the orbit is usually possible even in late treated cases with strabismus surgery. The need for secondary strabismus surgery in such cases may be explained by the fact that delay in the treatment of blow-out fractures will result in fibrosis of the injured orbital tissue, and this fibrosis with markedly displaced extraocular muscles results in less favourable outcome (Demer, 2001).

2.9. Patient perception and quality of life:

Quality of life (QOL) measures assess the individuals' perceptions in the context of their culture and value systems, their personal goals, standards and concerns (WHO, 1997). Health related QOL (HRQOL), however, is the assigned value to life duration when modified by the impairments in perception, all functional abilities and social relationships caused by diseases, injuries and their treatment (Patrick and Erickson, 1993).

HRQOL measurement has become increasingly important in patient management, as it measures the quality of care and clinical effectiveness in order to improve how people are feeling, not only in prolonging their lives (Guyatt *et al.*, 2001) Such measures are vital for health care providers to choose between different treatment options and approaches (Chen and Whigham, 2004). Furthermore, the use of HRQOL measurement has been advocated in clinical interventions by a number of authors, because quality of life is not determined by pathological processes alone, and the impact of health problems on functional, psychological, and social wellbeing of the patients should be considered (Allen *et al.*, 2009). Since the patient is the best source of information about his or her HRQOL, the developed practical tools usually rely on patient self-ratings (Casado, 2005).

On the other hand, controversy exists concerning the boundaries of HRQOL, and the level of the included individual patient's values. Gill and Feinstein (1994) argued that the aim of most measurements of quality of life in the medical literature seem to be incorrectly targeted, because quality of life is a personal perception, while HQOL instruments may be biased by some researchers' opinions. Moreover, HRQOL measures have been applied to 'quality of life' research without theoretical underpinnings and with little understanding of how the public, or patients, define or value the different components of life, as a result it can be measured using proxy data based on assumptions of what its constituents are (Bowling, 1995).

Leplege and Hunt (1997) criticized quantitative measures to assess HRQOL because they reflect the values and concerns of physicians and social scientists rather than of patients. Furthermore they referred to the lack of clear conceptual basis for HRQOL measures. They suggest that quality of life as an outcome could be defined more clearly if quality of life were replaced with the term "subjective health status."

2.9.1. Trauma and quality of life

QOL was developed originally for patients who have chronic, incurable diseases and health-related quality of life may be the most important outcome to be considered when deciding the most effective treatment to be delivered (Casado, 2005). However, there is developing interest in the literature regarding the influence of trauma on QOL. In his face-to-face interviews conducted with a nationwide sample of 1,518 elderly people in 2003, Krause (2004) found that exposure to lifetime trauma is associated with less life satisfaction in old age. He further referred to the need to develop interventions that help older people deal more effectively with lifetime trauma.

Holbrook *et al* (2001) used a Quality of Well Being Scale in a questionnaire for 1,048 eligible trauma patients. They found that functional outcome was significantly worse at each follow-up time point in females and Quality of Well-being scale scores were markedly and significantly lower at 6-month follow-up in females. This association persisted at 12-month and 18-month follow-up. The authors also found that females were significantly more likely to suffer depression at all follow-up time points. These findings were not affected by the mechanism or severity of injury. Moreover, Holbrook and Hoyt (2004) in a study using the Centre for Epidemiologic Studies Scale and the Impact of Events Scale found that women were significantly more likely to develop early combined depression and symptoms of acute stress reaction (SASR) at discharge from hospital. They stated that attention to this fact would be an important component of efforts in the improvement of trauma care and long-term outcome in mature trauma systems.

Holbrook *et al* (2007) also considered age as an important risk factor for low HRQOL. In their study of 401 trauma patients, aged 12 to 19 years, who sustained major trauma, they found that adolescents were associated with significant decrease in HRQOL throughout the 24-month follow-up period, compared with National Health Interview Survey (NHIS) norms for this age group. Ham (2008) did cross-sectional surveys on 24,327 Korean individuals with experience of unintentional injury experience, aged 19-65 years; these surveys were performed using face-to-face interviews. Twelve percent of the study sample had experienced an unintentional injury that required hospitalization at least once in their lifetime. He found that older, male patients, with less education and lower income, working in a blue-collar job, and being enrolled in medical aid programs were associated with increased unintentional injury. He also reported that this group have more risk-taking behavior, limitations in daily activities, suicide ideation, and drinking associated with their injury experience.

2.9.2. Facial trauma and quality of life

Shepherd *et al* (1990) conducted psychometric questionnaires for 122 patients treated for jaw fractures. The questionnaires were completed at outpatient appointments one week and three months after injury. They found that a short term psychological reaction is similar in victims of assault and accident, and half of their patient series were distressed one week after injury. They explained this by the temporary disfigurement, fear of permanent disfigurement or disability, and loss of self-confidence. They advised psychological support is important for all victims of trauma during the first week and that longer term support is more important for victims of assault than of accidental injury.

Sen *et al* (2001) further emphasized the psychological impact of facial trauma. In their study, 147 patients admitted for surgery following facial trauma over a seven-month period were assessed using three questionnaires, the Hospital Anxiety Depression scale, a modified University of Washington Quality of Life questionnaire and five non-validated facial trauma items, to record patient-derived levels of dysfunction. They reported anxiety and depression in 30% of the sample, despite the significant improvement in scores from preoperatively to one year. The findings of Hull *et al* (2003) highlighted the adverse psychological effect of maxillofacial trauma both immediately after the event and 4–6 weeks after injury. They suggested that proper assessment of injured patients must include psychological aspects.

Levine *et al* (2005) reported that facial trauma, significantly decreased satisfaction with life, and was associated with altered perception of body image. They listed a high association of incidence of post-traumatic stress disorder, alcoholism, post-trauma custody, unemployment, drinking, and marital problems following facial trauma. They concluded that facial trauma was associated with a significant negative social and functional impact. Furthermore, Ukpong *et al* (2008) found that patients with facial injuries are at risk of poor QOL after trauma and with a high incidence of depression throughout the follow-up period.

2.9.3. Orbital trauma and quality of life

To the best of our knowledge, the study of Folkestad *et al* (2006) is the only study to report QOL measurement in orbital trauma patients. In their study on orbito-zygomatic fractures, they compared doctor recorded and patient described symptoms using a visual analogue scale system (VAS) in a questionnaire given 5 times during a one year follow up period. They found that patients' profession and life style play important role in determination of the extent of their perception of eye motility problems. They also noticed that the degree of agreement between patient experience and doctor assessment of enophthalmos was low. However they found congruence between doctors and patients regarding facial asymmetry and diplopia.

In comparison, there have been many QOL studies for eye diseases using generic instruments, including WHO BREF, SF-36, MOS-24, and Hospital Anxiety and Depression Scale, and disease specific questionnaires, for example NEI VFQ-25 and Visual Function 14 index. However, not all these questionnaires cover common problems in orbital trauma patients, primarily in relation to diplopia and eye appearance domains.

Kahaly *et al* (2005) assessed the HRQOL for patients with Graves Ophthalmopathy using the Hospital Anxiety and Depression Scale, by a German adaptation of the Ways-of-Coping Checklist, and with the 36-item Short Form, respectively. They found that diplopia plays an important negative role on QOL for these patients. Bradley *et al* (2006) found that NEI VFQ-25 scores for patients with GO were lower for those with diplopia symptoms (composite score, 61) compared with those without diplopia (composite score, 90). Yeatts (2005) analyzed questionnaires for patients with GO for general and mental health (Short Form, or SF-12), self- perception and social functioning (adapted from the Dermatology-Specific Quality of Life Questionnaire, or DSQL) general visual function (51-item NEI-VFQ) and visual function specific to GO. He discovered that these patients have poorer self- image and significantly more disturbance in their sleep, social function, and work function because of facial disfigurement.

Burke *et al* (1997) asked 31 adults with poor ocular alignment to complete a self-reporting repertory grid about their facial appearance following strabismus surgery.

They found that before surgery, the majority of subjects reported various psychosocial concerns due to their unsightly strabismus. After surgery these subjects showed a significant improvement in interpersonal interactions. The authors concluded that strabismus surgery had a major effect on the quality of psychosocial functioning for the majority of adults undergoing such surgical procedures. Archer *et al* (2005) administered a modified version of the RAND Health Insurance Study quality of life instrument to parents or guardians of children with strabismus. The questionnaire was carried out by telephone interview, conducted by trained staff, before and 2 months after corrective surgery. They also found statistically significant improvements in social, emotional, and functional measures of the children's health status.

Jackson *et al* (2006) studied the psychological impact of strabismus on 46 participants, seen 6 weeks before and 3 months after corrective surgery. They used a Hospital Anxiety and Depression and social anxiety scale (Derriford Appearance Scale), and a quality of life measure (WHOQoLBref). They similarly reported that Strabismus surgery offers significant improvements to psychological and physical functioning.

Bradley *et al* (2006) advocated a GO specific questionnaire, reporting that the NEI VFQ-25, although including many items applicable to GO patients, showed significant ceiling effects in more than half of the subscales and lacked items on issues that are important to GO patients, such as altered appearance and ocular discomfort.

The nature of the facial disfigurement usually associated with facial or orbital trauma, for example enophthalmos, may have an influence on patient QOL. However, there is little evidence in the literature with regard to patient perception.

2.10. Summary

Blow-out fractures of the orbit have been a subject of controversy in more than one aspect. The controversy involves the mechanism of injury, the choice of treatment, timing of surgical intervention, surgical approach and choice of implant material.

However, the main area of disagreement around blow-out fractures of the orbit has been centred around the influence of surgical intervention on ocular motility outcome. Development of the CT scan has contributed in uniting of some of the concepts with regard to nature of the injury and its management. This resulted in a broadly agreed protocol for management which states that surgery is recommended not more than 2 weeks after the injury for cases with persistent diplopia and/or large fractures.

However, this management protocol did not resolve the problem of postoperative diplopia. This might be related to nature of orbital soft tissue injury associated with this trauma, which is further complicated by this tissue involvement in the fracture defect.

Disturbance of ocular motility disturbance has wide influence of patients' life, as shown in literature relating to Graves Orbitopathy. However, it has not been studied thoroughly in relation to orbital trauma. Consequently, it is not clear how postoperative diplopia would influence the patient's quality of life and whether clinician understanding for patient experience might improve the management outcome.

Chapter 3 Retrospective study (Ten year retrospective audit of orbital blow-out fractures)

3.1 Aim of the study

To determine the factors that influence diplopia management outcome in blow-out fractures of the orbit.

3.2 Objectives

To study the influence of demographic, radiographic and surgical factors on diplopia in blow-out fractures of the orbit.

To assess the prognostic role of Binocular Single Vision test in blow-out fracture management.

3.3 Materials and Methods

Its results will be used to help inform the research team of items of statistical importance in the outcome of blow-out fracture.

Over the last ten years all patients presenting to Newcastle General Hospital Oral and Maxillofacial Surgery department with diplopia following facial trauma have followed a formal multidisciplinary protocol. This protocol involved ophthalmological, orthoptic and maxillofacial assessment and data collection. The cumulative data will allow the study to examine: preoperative clinical, radiological and ophthalmic/orthoptic assessment, timing of surgical intervention, surgical technique and outcome.

Patients were identified from a database of orthoptic examination results held in the Ophthalmology Department, covering a period of ten years (1999 onwards). Ophthalmology and Newcastle Hospitals NHS Trust notes have been obtained and hand searched for the following information:

1. Demographic information
2. Date of injury
3. Date of presentation

4. Date of surgery
5. Clinical findings
6. Radiology findings
7. Ophthalmology examination
8. Orthoptic assessment
9. Surgical approach
10. Post-operative orthoptic assessment
11. Orthoptic patient follow-up

Inclusion criteria: Patients who sustained blow-out fractures of the orbit, both conservatively and surgically managed during the last 10 years.

Exclusion criteria: Patients who sustained orbital fractures involving orbital margins identified pre- or peri-operatively; patients who have been suspected to have blow-out fractures not confirmed by CT scan; and patients with history of amblyopia or monocular diplopia.

For the purpose of statistical analysis, cause of injury was divided into 4 categories; assault, fall, sport and others. Others include: RTA, self-inflicted injury, work injury, play fight, which were infrequently reported in this patient series.

The level of orbital tissue herniation was divided according to CT scan reports into 3 levels; zero for cases with no evidence of soft tissue herniation, level one for cases with orbital fat herniation and level 2 for cases with orbital fat and muscle prolapse into the fracture defect. This categorization was the most frequently applied by the reporting radiologists throughout the study period.

Orthoptic data included binocular single vision (BSV) scores for diplopia and uniocular field of fixation (UFOF) scores for ocular motility measurement (Figure 3-1). A weighted scoring template was used to quantify the field of BSV. The scoring template gives weighting to areas of the field of vision more commonly used in everyday life, with higher scoring given to primary position and depression and less scoring given for elevation and peripheral gaze (Sullivan *et al.*, 1992).

The fracture size measurement was adopted from Jin *et al* (2000). They assumed that the fracture defect resembles an ellipse. They used coronal and axial CT scans to measure the diameters of the fracture defect (A and B) for both orbital floor and medial wall fractures. They calculated the defect area from the formula π AB/4.

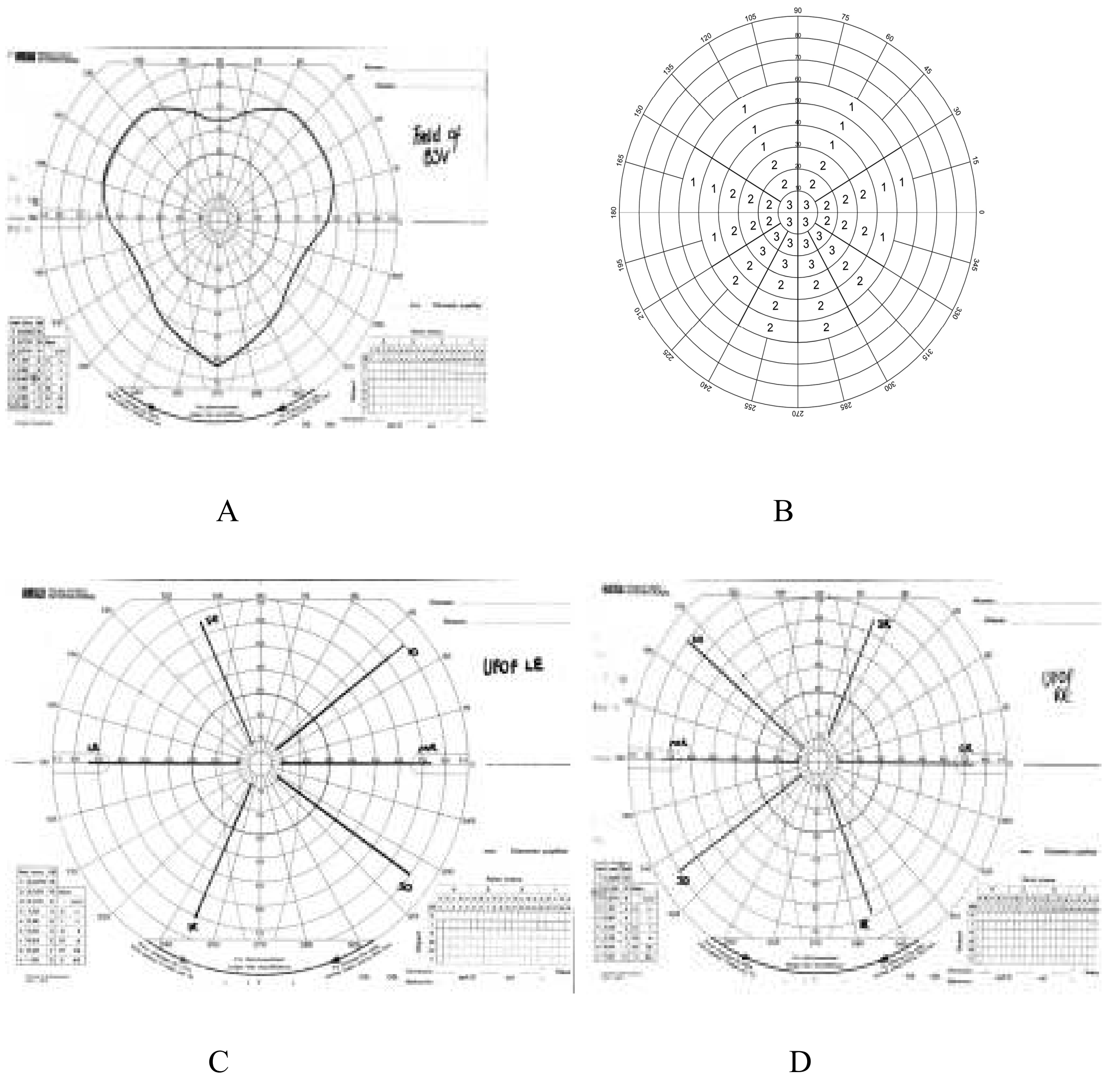


Figure 3-1 BSV chart for 'normal' patient (A), BSV scoring template (B), UFOF left eye and UFOF right eye (C and D)

Weighted BSV scores range from 0% (which indicates diplopia in primary position) to 100% (which indicates no diplopia). BSV scores were divided into 3 categories: low BSV category (0-60); moderate BSV category (61-80) and high BSV category

(81-100).

The UFOF score represents the collective score for the 6 extraocular muscles for each eye (Haggerty *et al.*, 2005). UFOF scores range from 60 -365. UFOF scores for both normal and injured sides were documented. UFOF scores were stratified into low score (60-240), moderate score (241-270) and high score (271-365) categories.

The low, moderate and high categories were based on the mean BSV and UFOF scores for both the surgically and conservatively managed population. The reason for categorization was to identify which BSV and UFOF categories would achieve different degrees of change (improvement) after surgery. This, hopefully, would provide an orthoptic based guide to assist in management choice.

Surgical outcome in relation to diplopia was subjectively divided according to the orthoptic report at the final patient visit into 4 groups, in which the orthoptist summarizes the patient's comments and perception about their double vision after surgery. In this coding process, the term "asymptomatic" was used for the first group of patients who have no complaint of diplopia; the second group are patients who were "not concerned" regarding any residual diplopia; the third group of patients were "symptomatic", with residual diplopia in one or more fields of gaze. Finally, the fourth group of patients was considered to require further measures, such as prism glasses or strabismus surgery, to correct disabling diplopia.

Data analysis was performed in SPSS (ver.17) using one way ANOVA, paired t-test, Wilcoxon signed ranks test, Mann-Whitney U test, Pearson, Spearman and Chi-square tests.

3.4 Retrospective study results

As with most of retrospective studies, the dataset for the study period was incomplete. Table 3-1 shows the available numbers of variables at the time of data collection. Cases with incomplete data were not excluded from the study, but where possible 'sub-group' analyses were performed. The variables and the number of cases in each statistical analysis test for available data are stated.

Name of variable	No. Of cases
Time from injury to orthoptic examination	210
BSV1	183
UFOF1 (injured side)	99
UFOF1 (normal side)	80
BSV2 (surgical group)	81
BSV2 (conservative group)	16
UFOF2 (injured side)	42
UFOF2 (normal side)	19
Tissue herniation	125
fracture side	214
fracture type	189
Fracture size (cm^2)	27

3-1: Available data for the general retrospective sample

3.4.1 Patient demographics

Two hundred and fifty seven patients were identified. Male to female ratio was 3:1 (Figure 3-2), with males more prevalent in both surgical and conservatively managed groups. Distribution of fractures by age is shown in (Figure 3-3). Injury was most common in the age groups 21-30 and 31-40. Chi-square test showed no statistical significant relation (p>0.05) between patients' age and the choice of management.

Figure 3-4 presents the frequency of the various reported causes of injury. As it can be seen from this figure, cause was similar in both conservatively and surgical managed groups of patients. Assault was the most frequently reported cause of injury. The term "Others" refer to various injury causes that were highly infrequent for the general sample and both conservatively and surgically managed patients. These include: self-inflicted injuries, work injuries, play fight, RTA and previous surgery. As shown in Figure 3-5. The highest number of cases occurred with injury caused by assault. Pearson Chi-square test showed a highly significant relation (p<0.001) between gender and the cause of injury (n=234).

Causes of blow-out injury by age group are illustrated in (Figure 3-6). It is apparent that assault dominates in 11-20 to 41-50 age groups. Fall dominates the higher age groups (51-60 onwards). The highest incidence of sporting injury by age group was reported in (11-20) and (21-30) age group. Chi-square statistical test showed that there was a significant relation (p<0.001) between the involved age groups and the cause of the injury.

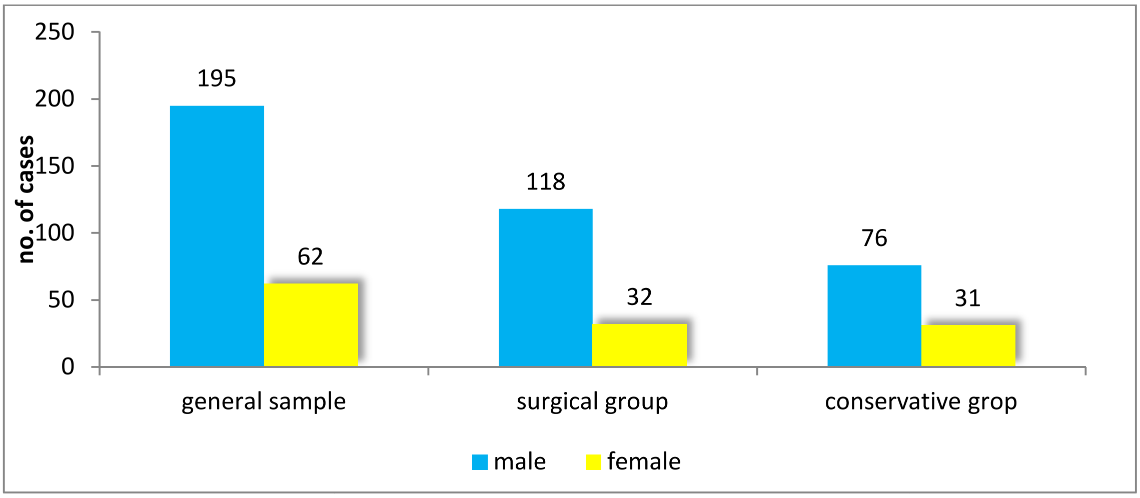


Figure 3-2: Distribution of blow-out fractures by gender and management (n=257).

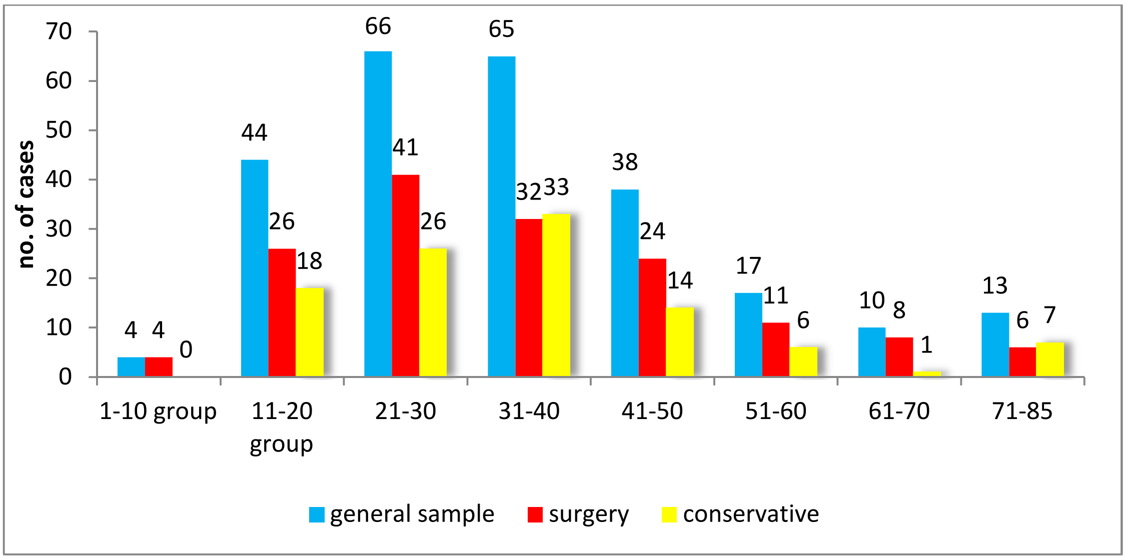


Figure 3-3: Distribution of blow-out fractures by age (n=257).

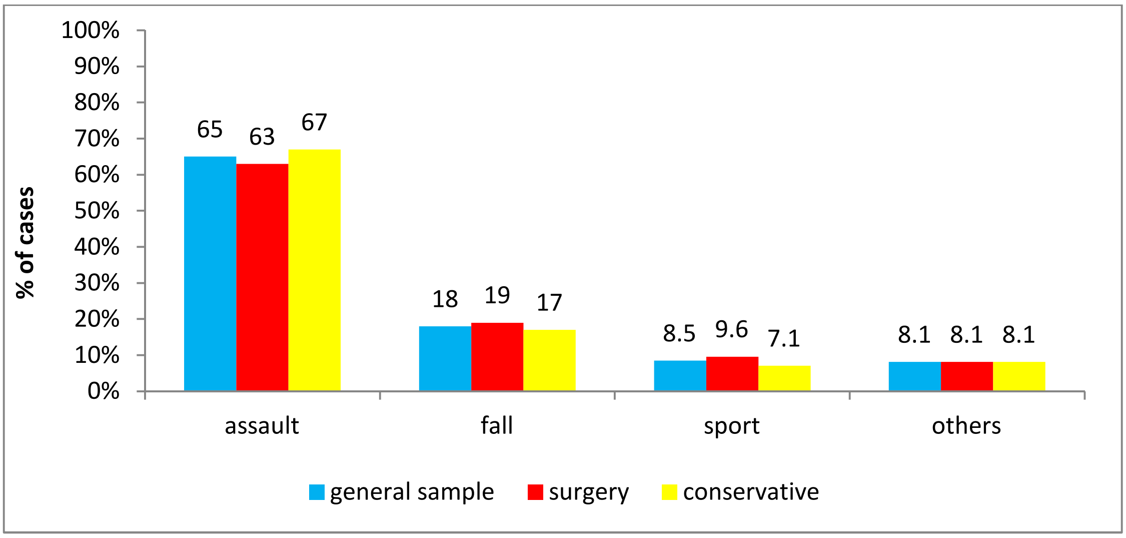


Figure 3-4: Percentage of cases by the causes of injury

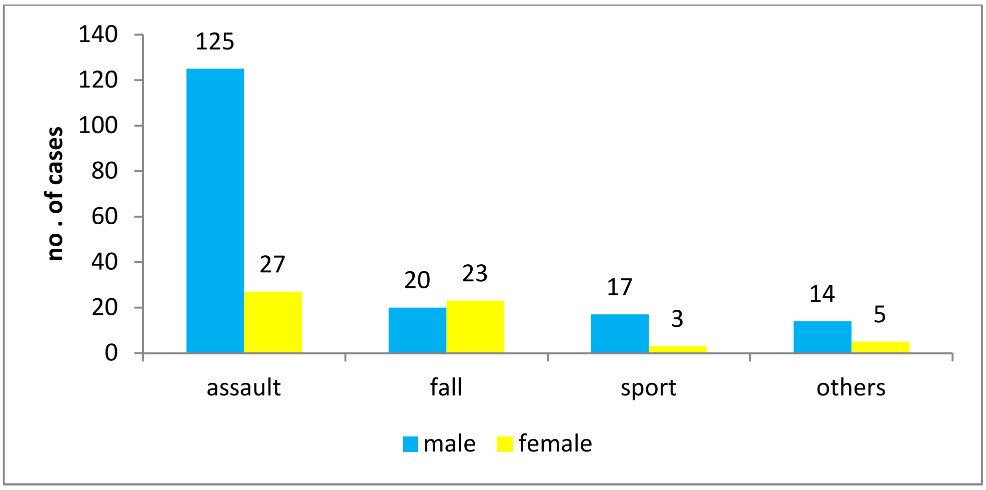


Figure 3-5: Causes of blow-out fracture by gender (no=234)

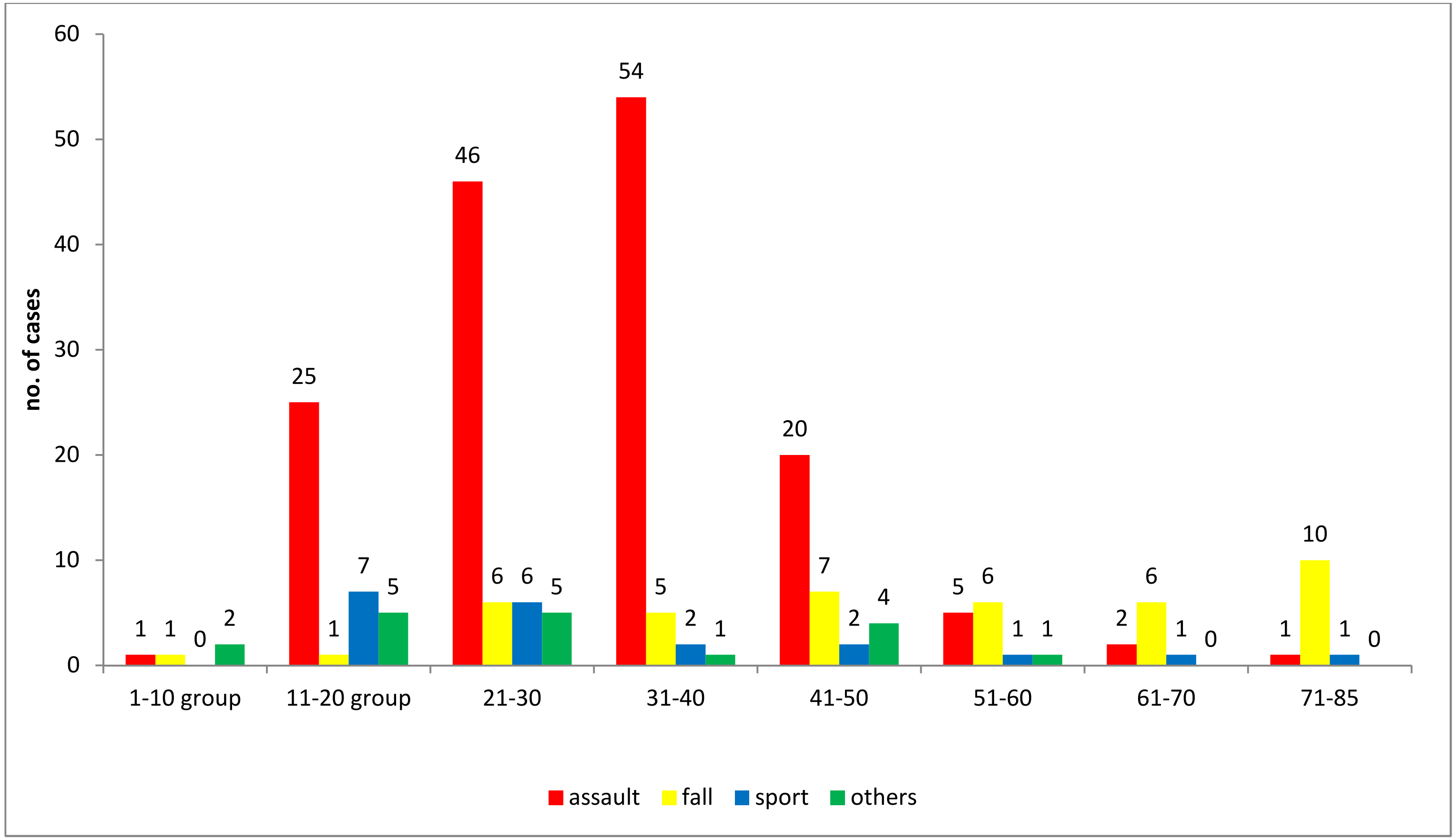


Figure 3-6: Mechanism of injury by age band

3.4.2 Clinical findings

Orbital floor fractures were the predominant site of blow-out fractures in the study (Figure 3-7). Figure 3-8 shows the frequency of the involved site by age. There is a significant relationship ($p<0.05$) between patients' age and the site of injury. There was no significant relationship between the causes of the injury and the site of blow out fracture (Chi-square test, $p>0.05$), or the cause of injury and the type of management. Similarly, no significant relationship (Chi square test, $p>0.05$) between fracture site and preoperative BSV, postoperative BSV (n= 149, 82), UFOF scores (n= 86, 35) or subjective outcome in relation to diplopia (n=68) was present.

Left side orbital blow-out fractures are more frequent than right side fractures as shown in Figure 3-9. The difference between the incidences of both sides is more evident in surgical group.

Figure 3-10 and Figure 3-11 demonstrate the frequency of the clinical findings associated with the blow-out fractures for the general retrospective sample, surgical group and retrospective groups. Diplopia reported the highest level of incidence compared with other features. Enophthalmos, on the other hand reported low incidence. Chi square test showed no significant relation ($p>0.05$) between gender and incidence of enophthalmos in the surgical group. Ophthalmic injuries were reported in about 1% of the cases examined. Those recorded were: corneal abrasion, conjunctival chemosis, hyphema, traumatic mydriasis, peripheral retinal haemorrhage, and commotio retinae.

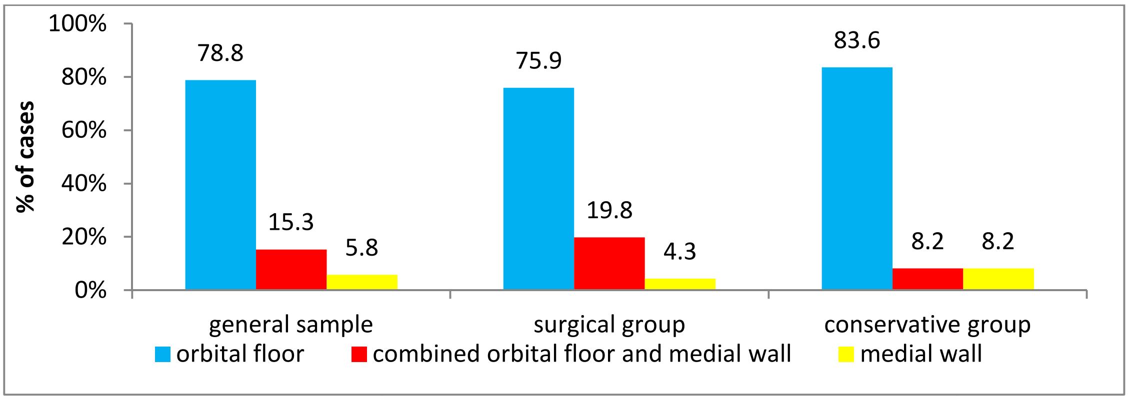


Figure 3-7: Percentage of blow-out fractures by sites of injury

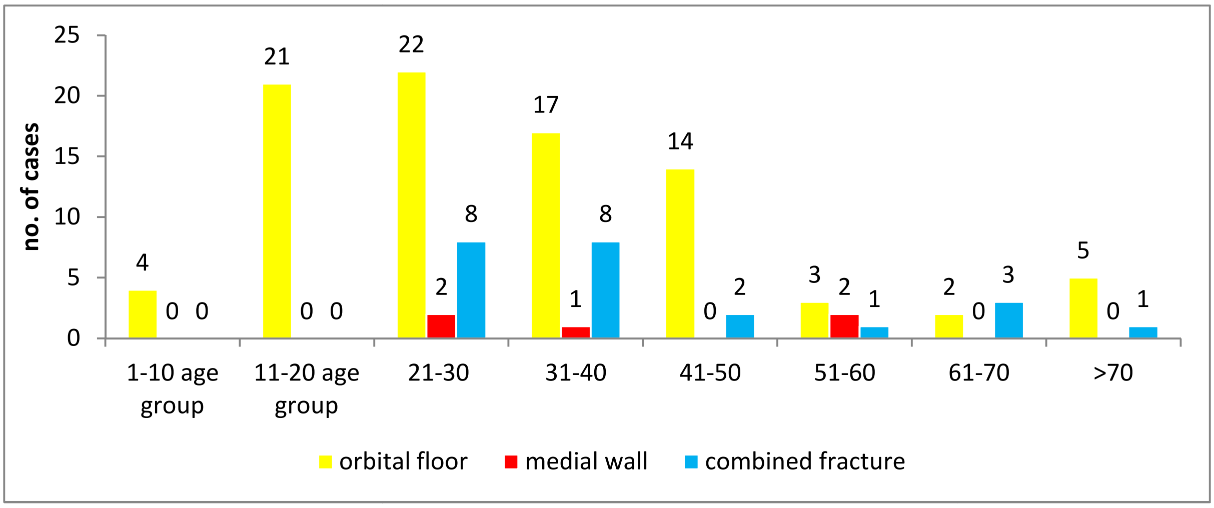


Figure 3-8: The site of orbital fracture by age band (n=116)

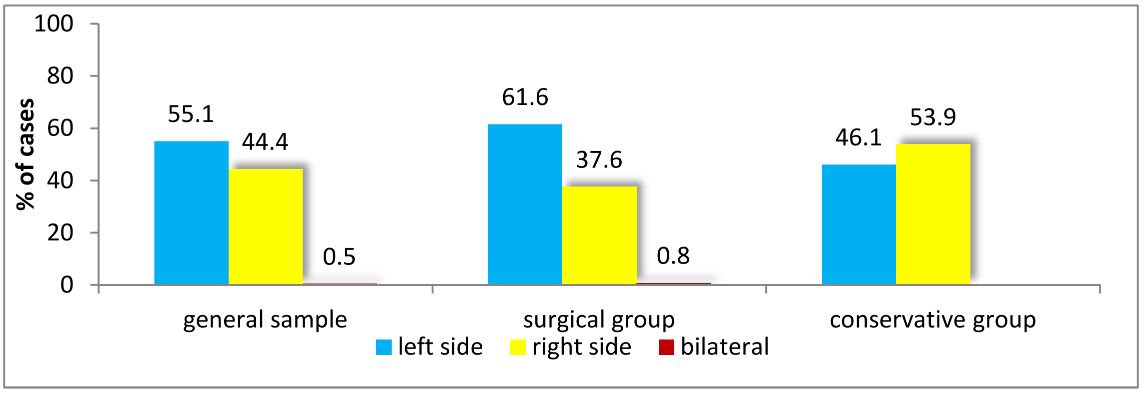


Figure 3-9: Percentage of blow-out fractures by side for the whole sample and both management groups

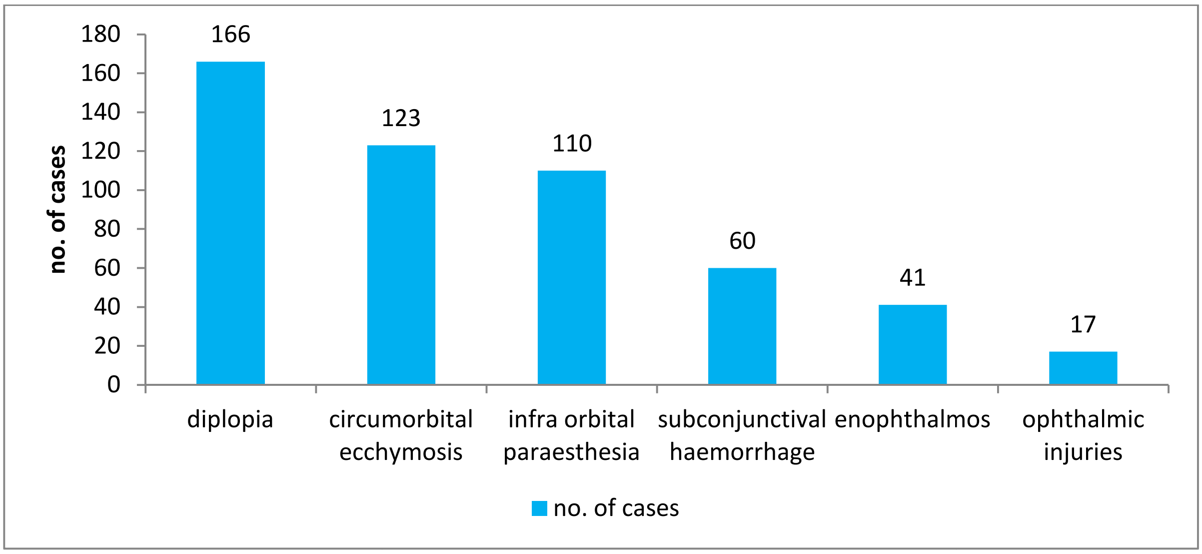


Figure 3-10: Clinical features of blow-out fracture by number of cases for the retrospective sample

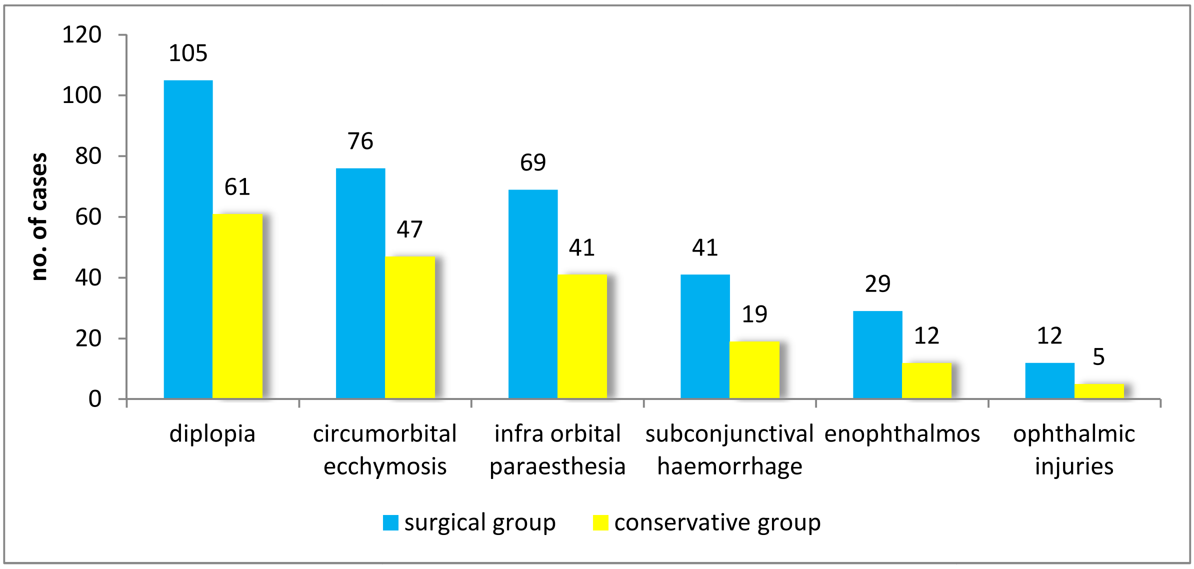


Figure 3-11: Clinical features of blow-out fracture by number of cases in both management groups

3.4.3 Orthoptic findings

Table 3-2 and Table 3-3 provide the descriptive statistics for orthoptic examinations for the retrospective sample in general and both management groups. The median time between injury and preoperative orthoptic examination in both management groups was 11 days.

A Pearson correlation test showed no significant relation between age of patients and both

BSV1 and BSV2 scores. Chi-square test showed no statistically significant (*p*>0.05) relation between gender and both pre-operative and postoperative diplopia categories (n=184, 101 respectively). It also did not show significant statistical relation between gender and preoperative and postoperative UFOF scores (n=99 and 44 respectively). Similarly, the cause of injury (n=176) was not significantly related (*p*>0.05) to BSV1 categories (Chi-square test),

Orthoptic test (BSV)	**Minimum**	**Maximum**	**Mean**	**SD**
BSV1 (1ST BSV) general sample	0%	100%	66.24%	32.838
BSV1 (1ST BSV) conservative group	0%	100%	82.86%	22.433
BSV1 (preoperative) surgical group	0%	97%	54.17%	33.98
BSV2 (postoperative BSV)	0%	100%	73.47%	21.393

Table 3-2: Descriptive statistics for the BSV for the retrospective sample, conservative group and surgical group

Orthoptic test (UFOF)	**Minimum**	**Maximum**	**Mean**	**SD**
UFOF1 general sample (injured side)	61	334	240.21	49.578
UFOF1 conservative group	191	342	268.87	31.755
UFOF1 surgical group	61	334	240.21	49.578
UFOF2 (postoperative UFOF)	136	335	260.72	32.898
UFOF1 general sample (normal side)	202	265	284.96	28.471

Table 3-3: Descriptive statistics for UFOF for the retrospective sample, conservative group and surgical group

Figure 3-12 demonstrates how BSV categories are distributed by age groups for surgical patients. For (41-50) age group (0-59) category is predominant, whereas in (11-20) age group (81-100) is predominant. As shown in Figure 3-13, high BSV category (81-100) dominates the BSV distribution in all age groups of conservatively managed patients.

It has been found that there is a statistically significant relationship (p<0.05) between age of the patients (no=99) and uniocular field of fixation (UFOF1) for the injured side (Pearson correlation). Conversely age was not statistically related to diplopia (BSV1) for the general sample (no=183), or preoperative diplopia (no=106) and postoperative (no=81) diplopia (BSV2) for the surgical group (Pearson Correlation).

Figure 3-14 compares BSV categories in surgically and conservatively managed patient groups. The low BSV1 category for the surgical group showed highest frequency of cases, whereas the high (81-100) BSV group recorded the highest percentage in the conservative group. As the figure implies, there is a highly significant difference (p <0.001) between BSV1 for surgical and conservative groups (Mann-Whitney U test).

Figure 3-15 demonstrates BSV scoring using weighted template for 2 patients; one was conservatively managed (BSV=90%) and the other was a surgically managed patient with preoperative and postoperative BSV scores (24% and 72% respectively). The shaded area represents the area of single vision.

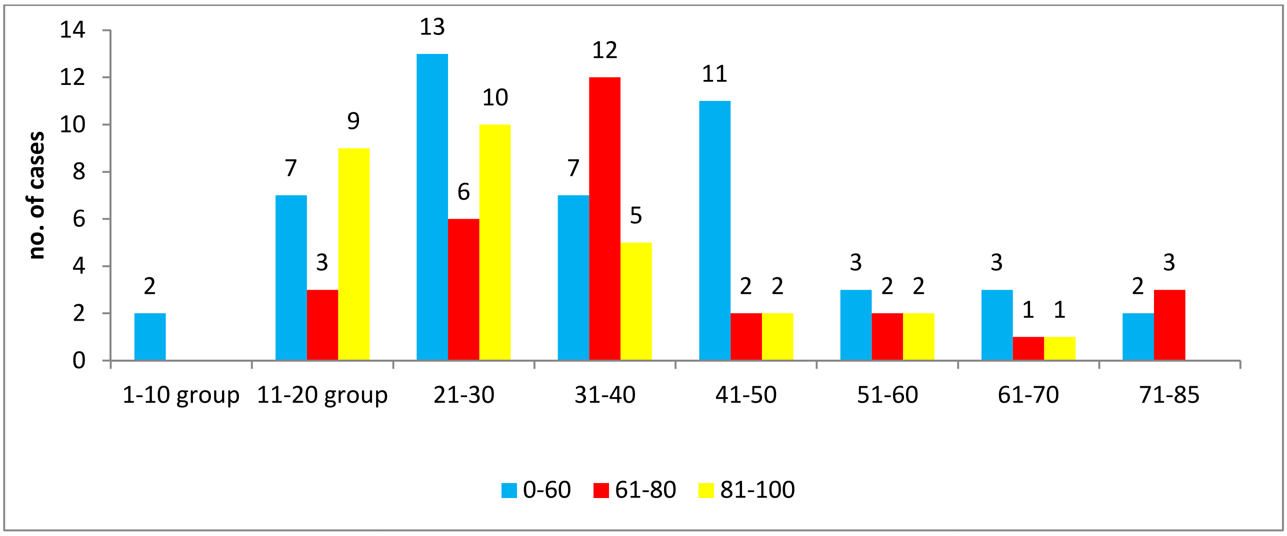


Figure 3-12: Age group by BSV1 category for the surgical patients

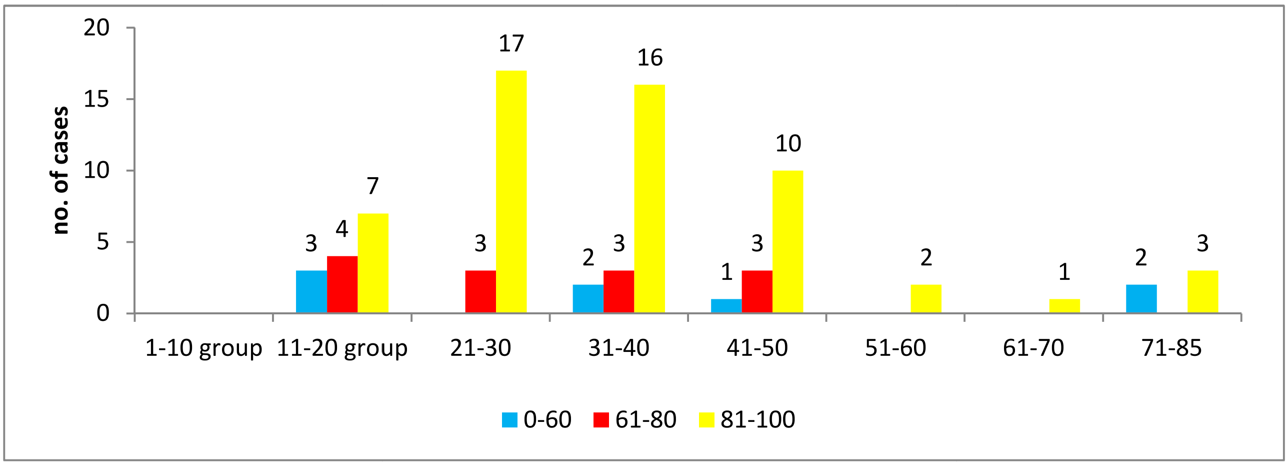


Figure 3-13: Age group by BSV1 for the conservative group

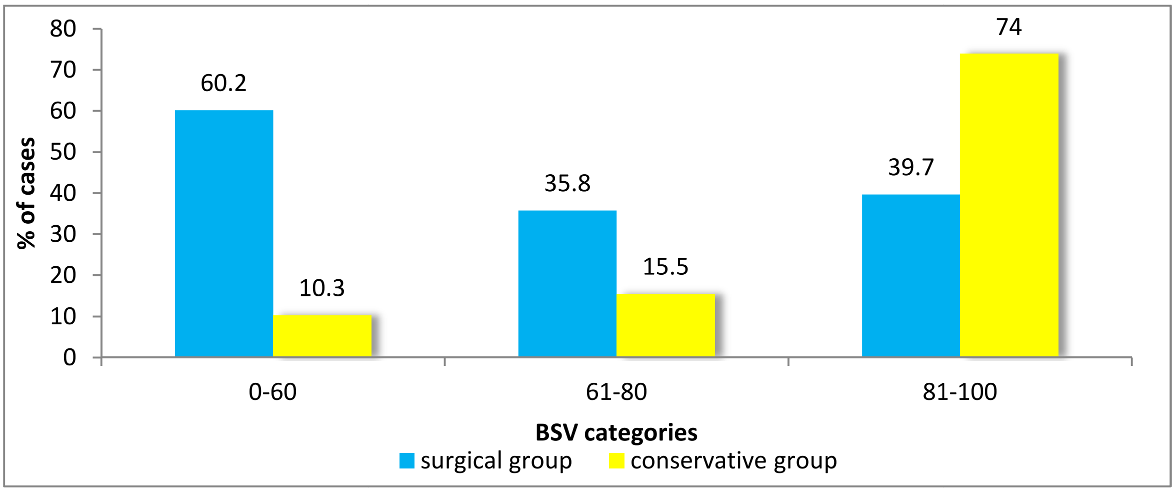
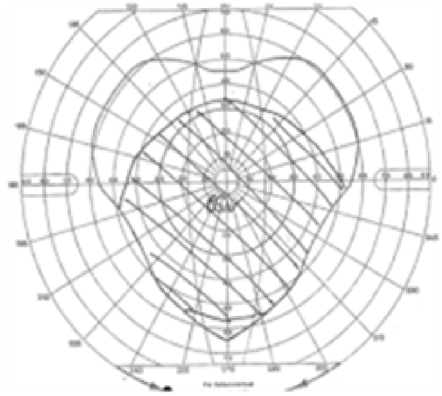


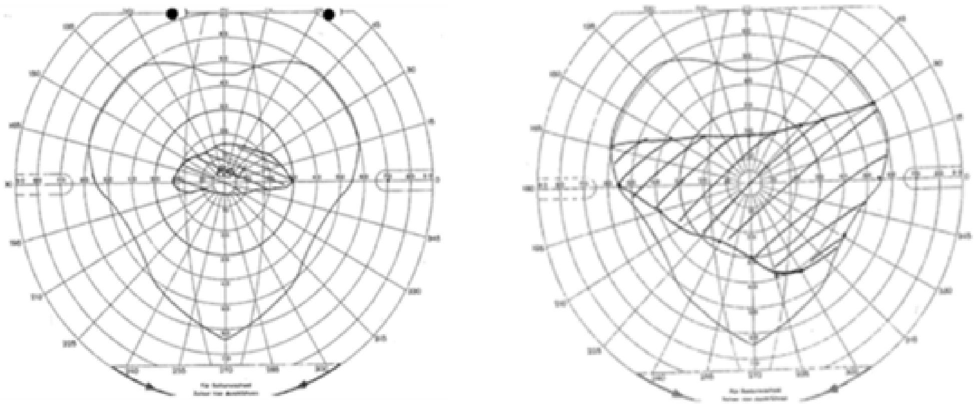
Figure 3-14: Percentages of cases for BSV1 categories in both surgical and conservative groups

A Pearson correlation, showed a highly statistically significant relationship ($p<0.001$) between preoperative UFOF1 and BSV1scores (n=93), which is clearly demonstrated in Figure 3-16. There is also a highly significant relationship between UFOF1 and BSV2 in the surgical group (n=44, Pearson correlation, $p<0.01$). There is a highly significant relationship ($p<0.001$) between BSV1 & BSV2 (n=70) in the surgical group. As shown in Figure 3-17, the improvement level in mean BSV score is not similar for the three BSV categories. The figure demonstrates that BSV improvement decreases with the increase of BSV1 category. The lower the BSV category the higher level of improvement in the mean score can be seen. There is a highly significant improvement ($p<0.001$) in the lowest BSV category. The improvement is also significant ($p<0.01$) in the mid BSV category (Wilcoxon Signed Ranks Test). Unfortunately, there was a decrease in the mean BSV postoperatively for the highest BSV group, although not statistically significant. However, there was a significant difference ($p<0.05$) in BSV score for the high BSV category (n=11) in the conservative group (paired t-test). Paired t-test showed no statistical significant changes ($p>0.05$) in cases with BSV score below 80 (n=4).

Wilcoxon Signed Ranks Test showed significant difference between UFOF1 and UFOF2 scores in surgically managed group. Figure 3-18 demonstrates that this imporvement in the in the lower UFOF category group. Whereas, there is a decrease in post UFOF scores for mid and high UFOF score categories..



(a) BSV1 (90%) for conservatively managed patient



(b) BSV1 (24%) for surgically managed patient (c) BSV2 (72%) for the same patient

Figure 3-15 (a) BSV score for conservatively managed patient. (b and c) Preoperative and postoperative BSV score for surgically managed patient.

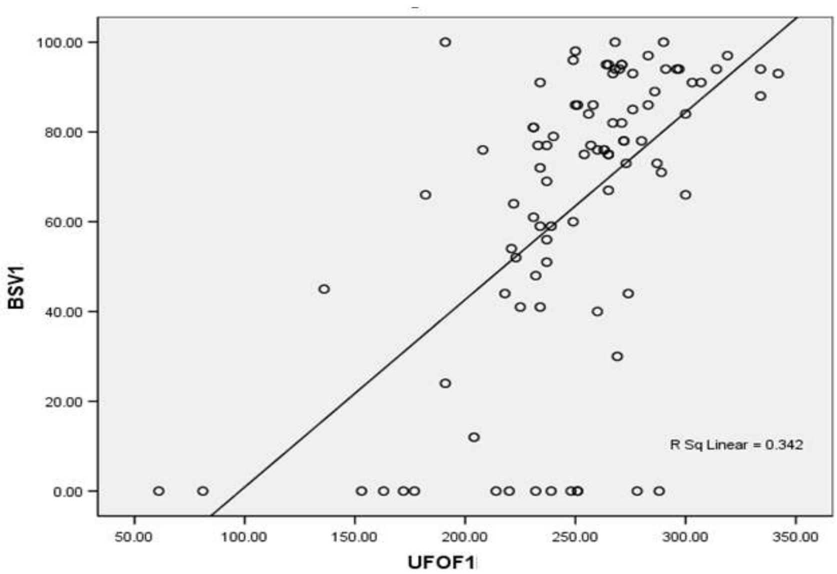


Figure 3-16: Scatter plot for the relation between preoperative BSV1 and UFOF1

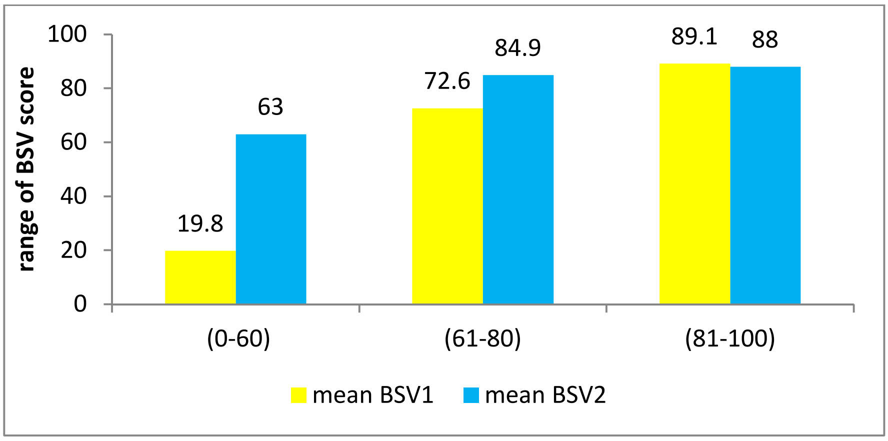


Figure 3-17: Changes in the means of BSV categories for surgical group

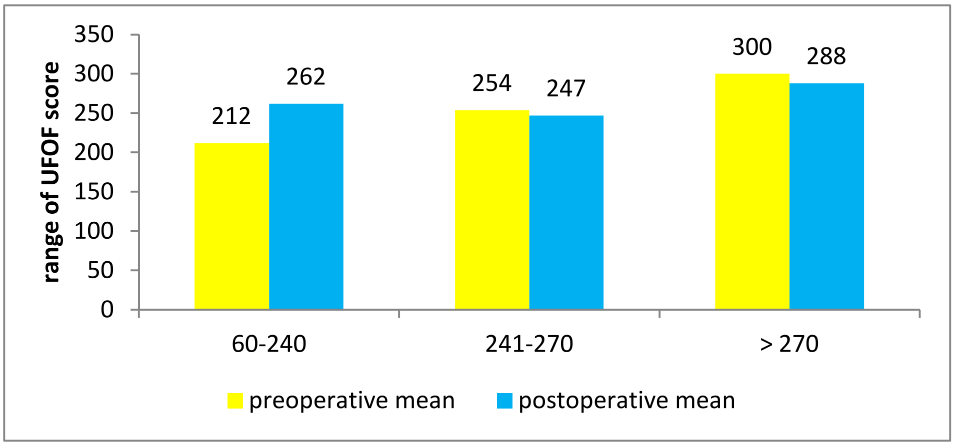


Figure 3-18: changes in the mean UFOF categories for surgical group

3.4.4 CT scan findings

The number of CT scan reports for blow-out fracture cases was 127. These reports usually record the fracture site (floor, medial wall or both), the position of orbital tissue in relation to the fracture, any evidence of orbital tissue entrapment or herniation, globe position and associated bleeding or haematoma.

Our data showed no significant relation ($p>0.05$) between the level of tissue herniation and age, gender (n=125), cause of injury (n=120), site of injury (n=122), and side of injury (n=121) (Chi-square test). Spearman correlation test also showed no significant relation between herniation level and patients' age (n=125).

Figure 3-19 shows the percentage of cases for the 3 levels of tissue herniation, as can be seen, orbital fat herniation was reported most frequently. Orbital fat herniation was reported in all but one case, with medial wall fracture. Orbital muscle entrapment, as opposed to herniation, was reported in only 2 cases (1.57%).

The level of tissue herniation for both management groups is shown in Figure 3-20. This figure shows that almost all the surgical group reported with tissue herniation. There is an obvious difference between both management groups in the percentage of cases with no herniation and extraocular muscle herniation, while cases with orbital fat herniation show a comparable percentage. The difference between both management groups in the level of tissue herniation was found statistically (Mann-Whitney U test) significant ($p < 0.05$).

Figure 3-21 demonstrates how the mean scores for both BSV and UFOF decrease gradually with the increase in extent of tissue prolapse in the fracture defect. There was a significant, though weak, relationship between tissue herniation and both BSV score ($p<0.01$, $r=-0.30$) and UFOF score ($p<0.05$, $r=-0.27$), the influence of orbital muscle herniation being more evident on mean BSV scores.

The influence of orbital muscle herniation on BSV is clear in Figure 3-22. Most of the cases (60%) in the low BSV category had orbital muscle herniation, with no tissue herniation reported in only 8.5% of the cases.

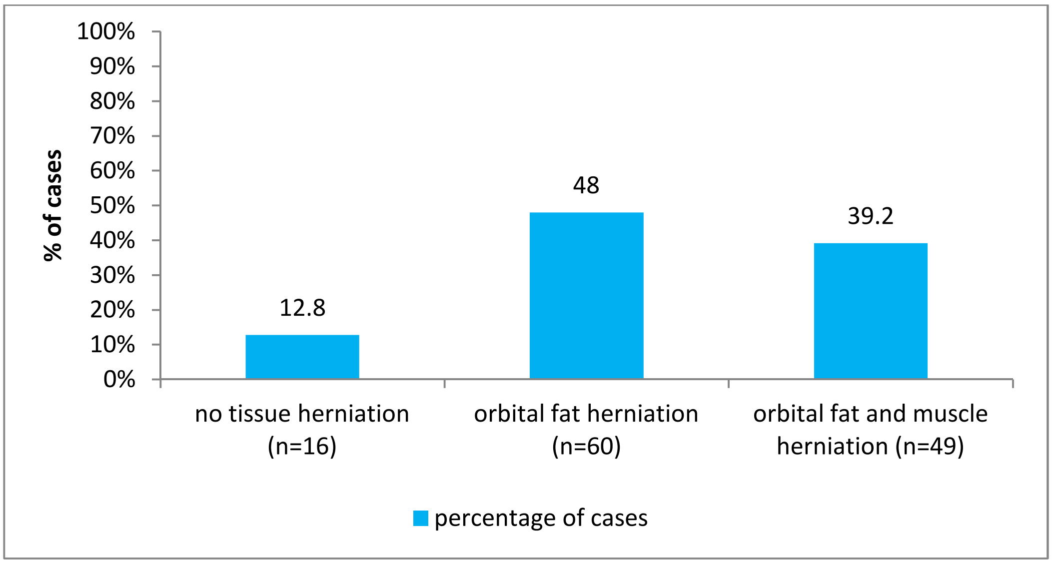


Figure 3-19: Percentage of cases for levels of tissue herniation for the general retrospective sample (n=125)

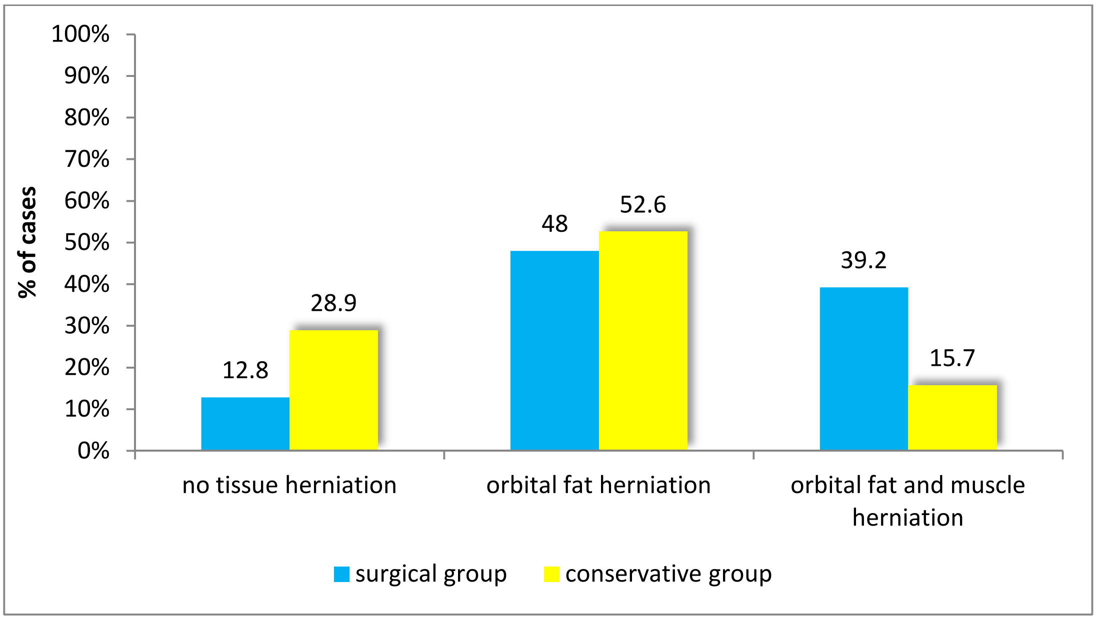


Figure 3-20: Percentage of cases for each level of herniation in both management groups

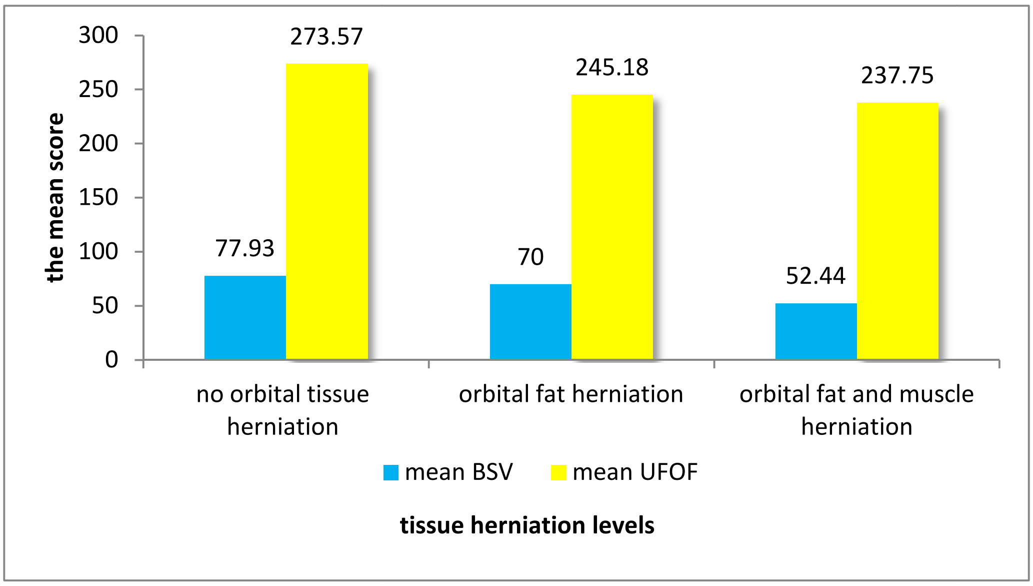


Figure 3-21: Mean BSV and UFOF scores for the 3 levels of orbital tissue herniation for the whole retrospective sample.

level of herniation (general sample)	BSV1 mean	BSV1 median
no tissue herniation	77.9	91
orbital fat herniation	70	81
orbital muscle herniation	52.4	60

Table 3-4: mean and median BSV scores for the 3 levels of tissue herniation in the general sample

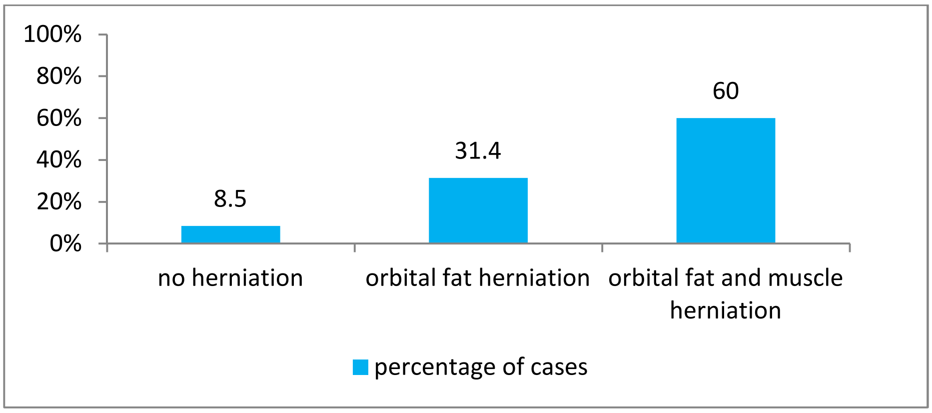


Figure 3-22: Percentages of cases with each level of tissue herniation for low (0-60%) BSV category

Table 3-4 shows that the mean and median BSV values for orbital muscle herniation in surgical group are within the lower BSV score category, while the mean and median BSV values for no tissue herniation and orbital fat herniation lie within middle and high BSV categories respectively. The mean for no tissue herniation and orbital fat herniation lie within the same moderate BSV category, also the median for both levels of tissue herniation lie within the same, although now high, BSV category.

Mann-Whitney test showed no significant difference ($p>0.05$) for both BSV and UFOF scores between cases with “no tissue herniation” and “orbital fat herniation”. Whereas there was significant difference ($p<0.05$) for both BSV and UFOF scores between “no tissue herniation” and “orbital muscle herniation” cases.

Our data showed that the level of tissue herniation is not a significant (Spearman correlation test) influential factor on postoperative BSV score (n=51), BSV score improvement (n=46), postoperative UFOF score (n=17), UFOF score improvement (n=21) nor on the final outcome in relation to diplopia (n=48).

Table 3-5 gives a detailed blow-out fracture dimensions for both orbital floor and medial wall fractures in our study sample. There is, however, no obvious difference between the mean sizes of orbital floor and medial wall fractures. T-test showed no significant difference ($p>0.05$) between males and females in relation to the size of the fracture in the surgical group (n=23).

No significant relation ($p>0.05$) was found between the size of the fracture and the level of tissue herniation (Mann-Whitney U test) for the general sample (n=25). Pearson Correlation test did not show significant relation between fracture size and BSV1 (n=23), UFOF1 (n=16) for the general sample. Pearson Correlation test, also, did not show significant relation ($p>0.05$) between size of the fracture and both BSV2 and UFOF2 for the surgical group (n=14, n=7 respectively).

orbital floor (n=26)	*minimum*	*maximum*	*mean*
length (cm)	0.45	2.7	1.01
width (cm)	0.3	1.9	0.96
size (cm^2)	0.141	4.02	0.83
medial wall (n=16)	*minimum*	*maximum*	*mean*
length (cm)	0.45	2.4	1.25
width (cm)	0.25	2	0.83
size (cm^2)	0.177	2.35	0.84

Table 3-5: Dimensions and sizes of blow-out fracture (n=27)

3.4.5 Surgical findings

Surgery was performed for 152 patients, leaving 107 patients who were conservatively managed.

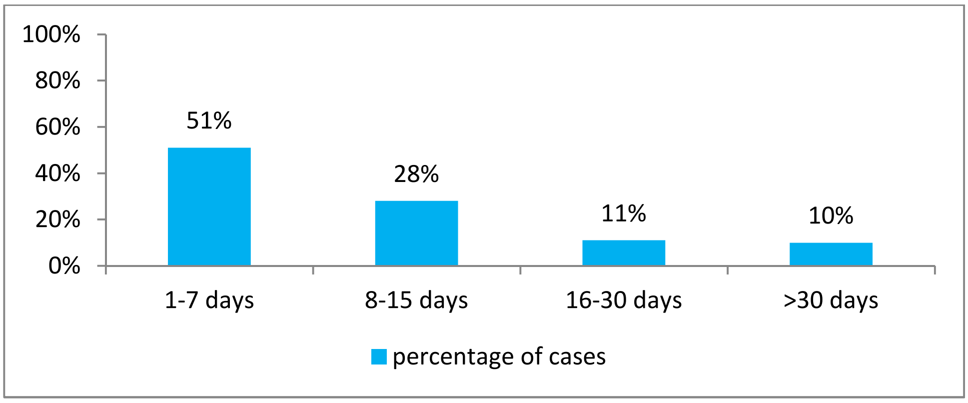


Figure 3-23: Timing of surgery

Figure 3-23 shows that 90% of the cases were treated within 30 days after the injury. More than half of these were treated within 7 days of injury. No significant relation (Pearson correlation) was noted between surgical timing and both BSV2 and BSV score improvement for the surgical group (n=62, n=56 respectively). Similarly, no significant relation (Pearson correlation) was observed between surgical timing and UFOF2 (n=29) or UFOF improvement (n=27). However, cases treated within one month (n=49) showed significant improvement (p <0.001) in their BSV scores, while cases treated after one month (n=7) did not show significant improvement (p>0.05) in BSV score, despite the fact that the mean preoperative BSV1 score for the cases treated after one months was 54.1.

A subciliary skin approach was used in majority of cases (Figure 3-24). Transconjunctival and transconjunctival with lateral canthotomy approaches were also used, but to a far lesser extent. Chi-square correlation test showed no significant relation between the surgical approach and BSV2 (n=56), UFOF2 (n=30) and both BSV and UFOF score improvement (n=52, N=27 respectively).

As shown in Figure 3-25, silastic sheet was the preferred implant material for the surgical reconstruction in orbital defects, followed by titanium mesh. Within the titanium group, 2 orbital defects were reconstructed using both silastic sheet and titanium mesh. Bone grafts, mostly calvarial bone graft, were the least used implant material. In one case no implant material was used to repair the orbital floor defect, with fracture reduction only. Mann-Whitney U test showed no significant difference (p>0.05) in the size of the fracture between silastic material and titanium mesh reconstruction (n=17).

Figure 3-26 shows a descending pattern for mean BSV2 with highest BSV mean for bone graft, followed by silastic implant and finally the lower mean BSV2 score for titanium mesh. However, there was no significant relation (*p*>0.05) between the choice of implant material and BSV2 (n=56). There was, also, no significant relation between BSV score improvement for the surgical group (n=51). Chi-square test also did not show significant statistical relation between the choice of implant material and UFOF score improvement (n=26).

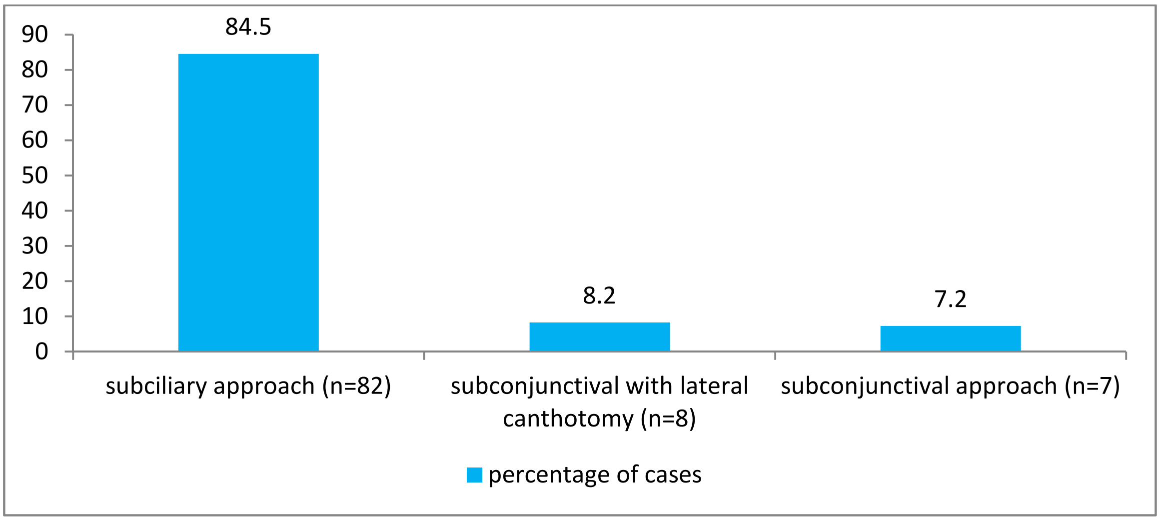


Figure 3-24: Surgical approach (n=97)

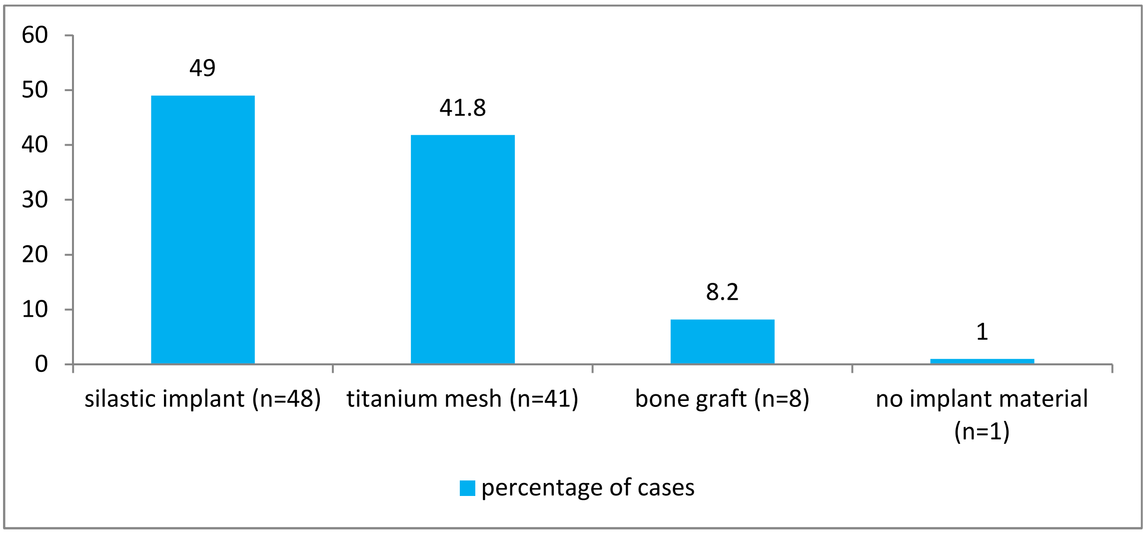


Figure 3-25: Implant materials used for the reconstruction of orbital wall defects (n=98)

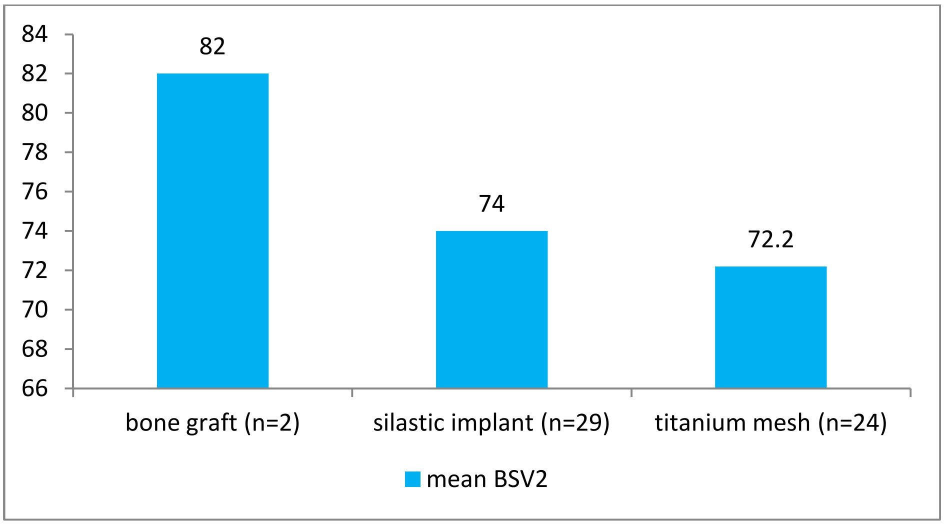


Figure 3-26: the mean postoperative BSV for each implant material (n=55)

3.4.6 The surgical outcome

Surgical complications were relatively low in this case series. Out of 152 patients who underwent surgery, 4 cases required a second procedure for removal of silastic implant. A silastic implant had to be replaced by a bone graft for persistent diplopia in one case. In the remaining 3 cases silastic was removed because of persistent diplopia and discomfort.

Four cases reported with postoperative enophthalmos, orthoptically considered as "mild". One case reported with 1mm enophthalmos, the cosmetic appearance of which did not concern the patient. In a second case the patient refused to have a calvarial bone graft for correction of both enophthalmos and diplopia against the surgeon's advice, titanium being used as a compromise. The third case reported both enophthalmos and diplopia in upward gaze.

The final outcome of the treatment for the surgical group in relation to patient appreciation of diplopia is shown in Table 3-6. The symptomatic group of patients was largest in our sample. These patients, although demonstrating variable degrees of improvement, were still aware of diplopia, mainly in up and/or down gaze. These patients were variously reported as coping with their double vision or still bothered by their diplopia. Four patients required further intervention; 3 out 4 in this group started to use prism glass or blender, the last patient required strabismus surgery.

Figure 3-27 shows a moderate decrease (within 10%) in BSV2 score with the increase of surgical timing within one month of injury. The highest BSV2 scores were achieved when surgery was performed within one week. Despite this finding, Spearman correlation test did not show a significant relationship (p>0.05) between surgical timing and BSV2 score categories (n=55).

As shown in Figure 3-28, both lower BSV1 and BSV2 were associated with less favourable subjective outcome. Significant statistical relation has been found between both BSV1 (n=49) and BSV2 (n=51) in the surgical group and the final outcome ($p < 0.05$) and ($p < 0.01$) respectively. However, BSV improvement (n=56) has not been found to be significantly related ($p > 0.05$) to the subjective outcome in relation to diplopia (Spearman correlation). No significant relation has been found between UFOF1 (n=29) with final outcome in relation to diplopia (Spearman correlation).

Despite the fact that there was no statistically significant relationship between the level of tissue herniation and the final outcome in relation to diplopia (p>0.05), Figure 3-29 shows that 70.5% of cases with orbital fat herniation were within “asymptomatic” and “not aware or concerned” categories, whereas 58% of the cases with orbital muscle herniation reported with “symptomatic” and “required other measures” categories.

There was no significant relation (Spearman correlation) between surgical timing and diplopia final outcome (n=60). Chi-square test also showed no significant relation between surgical approach and implant material with the final outcome in terms of diplopia (n=55). Furthermore, patients’ age (Spearman correlation) (n=72), gender (n=88), cause of injury (Chi-square test), size of fracture (Pearson correlation) were not related to surgical outcome in relation to diplopia.

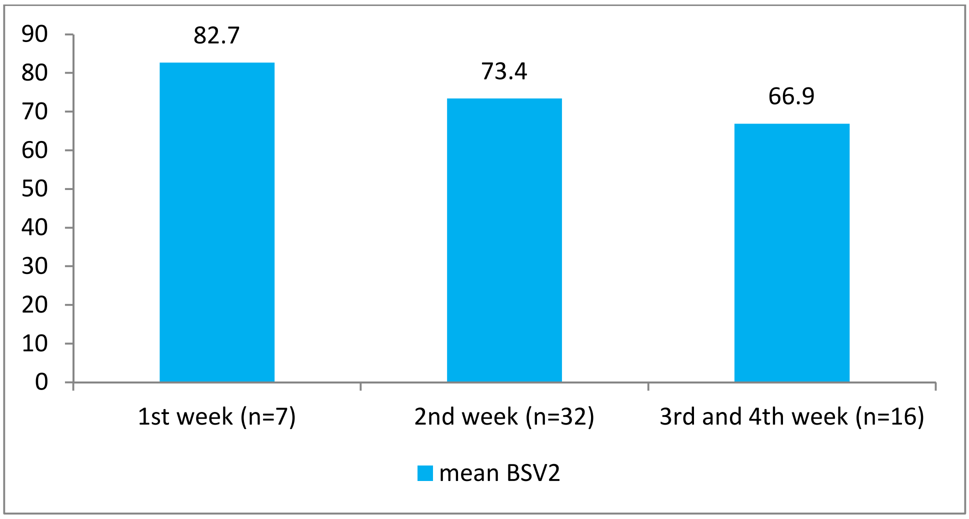


Figure 3-27 Mean BSV2 by surgical timing within 1st month (n=55)

Final outcome criteria	**no. of cases**	**(%) of cases**
asymptomatic	17	19.5
not aware or not concerned	26	29.9
symptomatic	40	46
required further treatment	4	4.6
total no.	**87**	**100%**

Table 3-6: The final outcome in relation to diplopia (n=87)

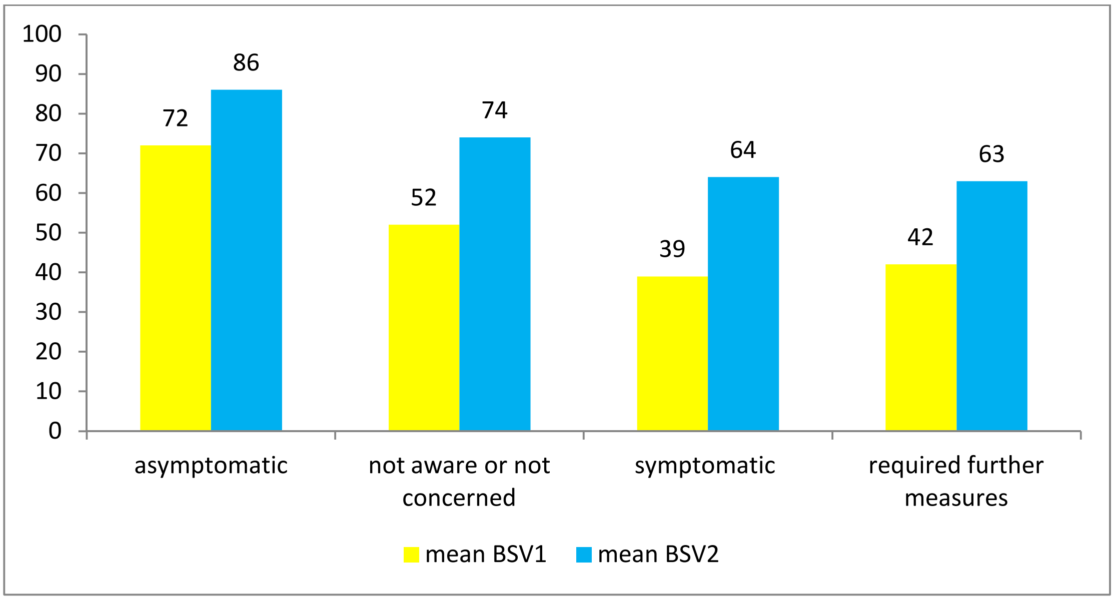


Figure 3-28: Mean BSV1 and BSV2 for outcome categories

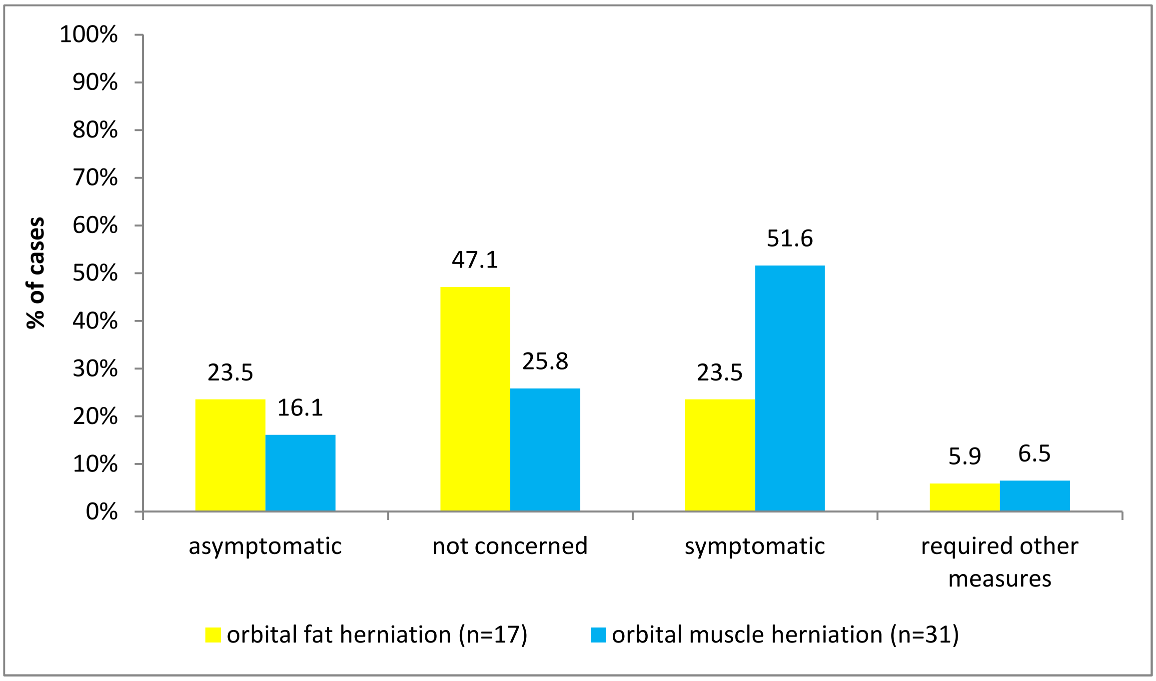


Figure 3-29: Percentages of cases for the final outcome by the level of herniation (only one case with no tissue herniation).

3.4.7 Patient follow-up time

Orthoptic follow-up period for surgery group ranged from 2 weeks to 13 months. As demonstrated in Figure 3-30 the general trend of follow up is that the number of cases decreases with the increase of frequency of follow-up visits. The average time between surgery and 1st orthoptic follow-up visit was 1.5 month, while the average time between the 1st and the 2nd orthoptic follow-up visit was 2 months. As shown in Figure 3-31, there is a highly significant (p<0.001) negative relation between the number of follow-up visits and BSV1 (n=88). Pearson correlation test also showed significant relation (p<0.01) between UFOF1 and the number of follow up visits (n=48). Pearson Correlation showed that BSV2 was statistically (p<0.05) related to follow up time (n=43) and number of follow-up visits (n=74). Whereas UFOF2 was not found to be statistically related (p>0.05) with follow-up time and number of follow-up visits (n=20, n=32 respectively).

Pearson correlation showed highly significant negative relationship (p<0.01) between BSV1 and follow-up time (n=44). It also showed a significant negative relation (p<0.05) between BSV2 and follow-up time (n=43). However, the relationship (p<0.05) between BSV score improvement and follow-up time (n=33) was positive.

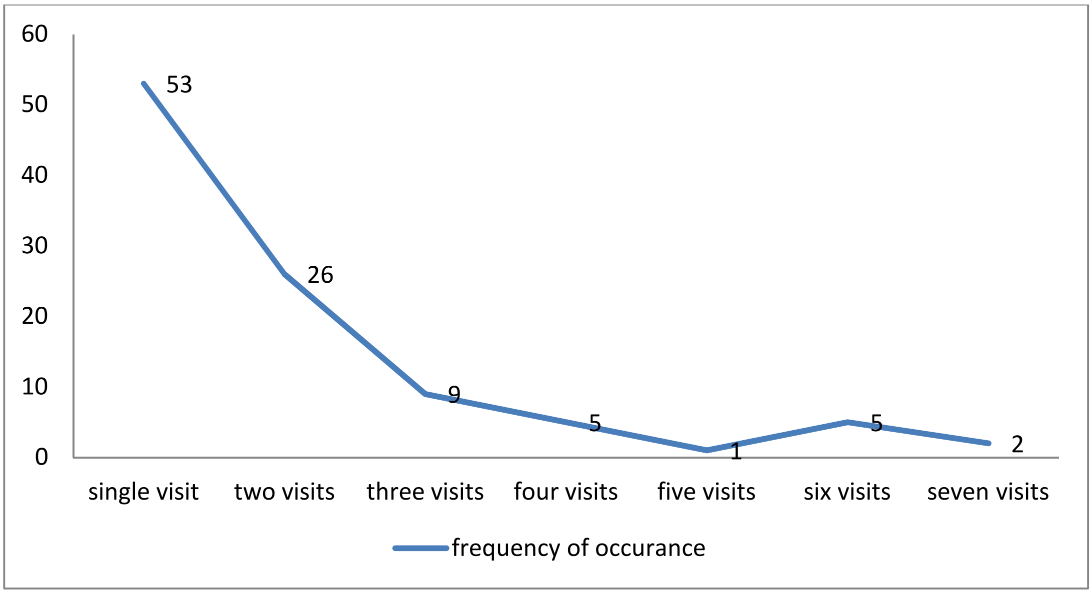


Figure 3-30: Frequency of orthoptic follow up visits for surgical patients (n=67). Cases with no follow-up visit were excluded (n=27).

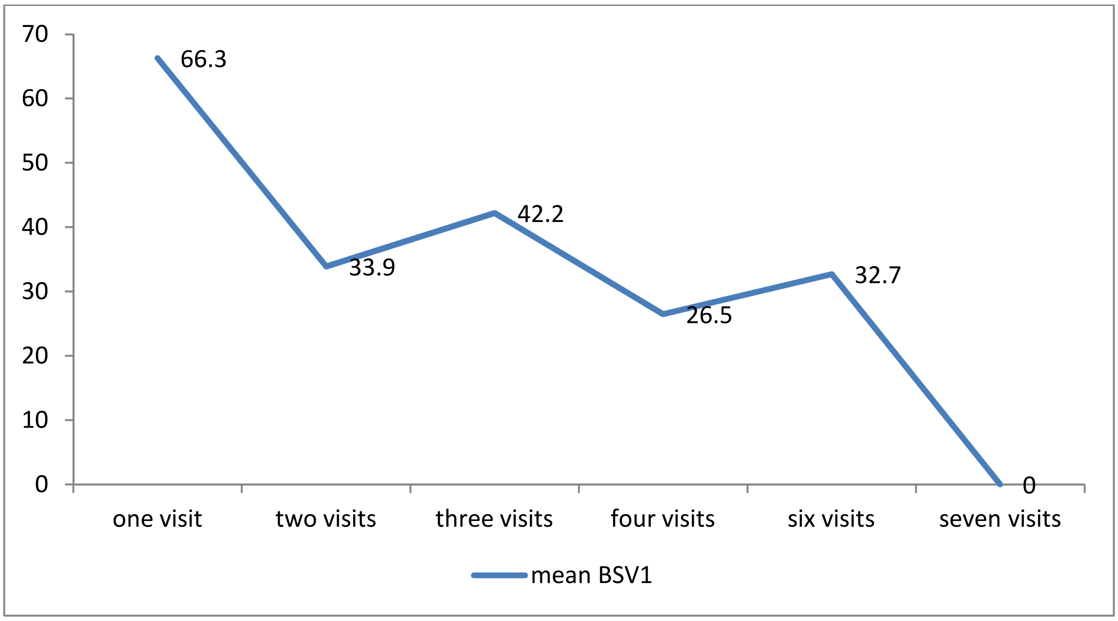


Figure 3-31: The number of follow-up visits by the mean of BSV1

3.5 Retrospective study discussion

3.5.1 Patient demographics

There is a paucity of data with regard to blow-out fracture studies compared to facial trauma studies in general, and the number of studies with which we had to compare our findings.

Our data showed that the difference in percentage between males and females in surgically managed group is higher than conservative group. Apart from the fact that that the percentage of diplopia in males (95.3%) was slightly higher than females (87.8%), there was no other data that explains this difference. Data analysis did not show that males were involved in more aggressive injuries, since no significant relation was found between gender and severity of diplopia (BSV1 score category) and no significant relation between gender and the level of tissue herniation. In terms of surgical decision based on treatment of enophthalmos or large fracture size, our data did not show any significant difference between the incidence of enophthalmos between males and females in the surgical group, also it showed no significant difference between males and females in terms of the fracture size. Subjective considerations from patient's and surgeon's side and their influence the choice for treatment must not be overlooked.

Our study data showed that assault was the major cause for injury for males. In agreement with our finding, assault was the most frequent cause of injury in other studies (Jones and Evans, 1967; Mustaffa *et al.*, 2008; Simon *et al.*, 2009). Assault followed by fall then sport was also reported by Gosse (2009), though in lower percentages. Chi *et al* (2009) also found that violent assault was the leading cause of fractures, followed by fall. Egbert *et al* (2000) found that interpersonal violence was the most common cause for injury in a young population. Cope *et al* (1999) and Koide *et al* (2003) reported assault, especially alcohol related, to be the main cause of injury in their series. Anecdotally, alcohol was frequently mentioned in our own assaulted patients' notes also.

Our finding disagrees with Rowe and Crowley (2003) who found that sport was the most common cause following assault, whereas falls were the second most common cause in our series. In their study Row and Crowley found that females were not involved in assault, while in our case series females constitute about 20% of such injuries. The cause of injury, however, was not statistically found to influence the management choice. The percentage of sport as a cause for injury in our sample disagrees with Jones (1994), who found that sport form one third of the causes of blow out fracture. This might be related to the types of sport in USA. Baek and Lee (2003), however, reported accidents as the most common cause in their series.

This study showed no relation between age and the cause of injury. It also showed that cause of injury is not an influential factor on both pre and post-operative diplopia and ocular motility scores and subjective outcome in relation to diplopia.

Our findings suggest that gender is not a highly influential factor on both pre and postoperative ocular motility and diplopia scores or the subjective outcome in relation to diplopia. This finding agrees with Brucoli *et al* (2011) who also found that gender is not influential factor on postoperative diplopia. It should be mentioned, however, that they used different tests for evaluation of diplopia (cover test, red glass test, and Hess-Lancaster test).

The highest incidence of blow-out fracture in this study was reported in (21-30) age group, which agrees with Chi *et al* (2009) finding, as they reported that (20-29) age group is higher than other age groups. However, in our sample, age group (31-40) reported almost the same frequency of incidence as (21-30) age group. Twenty one-thirty age group was also most prevalent among those patients managed surgically. Extreme age groups 1-10 and 61-70 years recorded the lowest incidence of blow-out fracture for all sample categories. This concurs with other studies which found that paediatric blow-out fractures are uncommon. The cause of injury in elderly patients was predominantly falls.

There is no agreement about the influence of age on ocular motility and diplopia in orbital fractures. In this study age was not found to influence preoperative diplopia score. Similarly, age was not found to be highly influential on postoperative BSV score and the subjective outcome in relation to diplopia. This finding agrees with Rowe and Crowley (2003), who found no relation between age groups and outcome of surgery in relation to ocular motility. However, this disagrees with Kim *et al* (2003) who found significant relation between age of patient and postoperative diplopia.

Our data showed that age had a negative influence on the preoperative ocular motility score (UFOF); as patient age increases the ocular motility score of the injured side decreases. However, our results did not show a relationship between age and UFOF normal side, suggesting that the injured UFOF is not the result of a general age related decline in motility. To the best of our knowledge this is the first study that has measured the influence of age on both normal UFOF and on the UFOF for the injured eye in patients with orbital blow-out fracture.

It worth considering that our study, unlike previous studies, includes demographic and clinical data for both conservative and surgical management groups. This may explain the reason behind some of the discrepancy with other studies' findings.

Apart from age influence on ocular motility score, demographic data does not seem to have a major influence over pre, post-operative diplopia and subjective outcome in relation to diplopia. This finding might explain the little interest over demographic data in other studies.

3.5.2 Clinical findings

Blow-out fractures occur predominantly in the weakest regions of the orbit: orbital plate of ethmoid bone and the orbital floor (Jones and Evans, 1967). In this case series, the occurrence of orbital floor fractures dominates both the conservative and surgically treated patients. A low incidence of medial wall fractures in our sample supports the findings of other studies (Evans and Fenton, 1971; Hosal and Beatty, 2002; de Silva and Rose, 2011; Baek *et al.*, 2003). Medial wall involvement including isolated and combined with orbital floor fracture occurred in 21% of the cases. This percentage agrees with of Dulley and Fells (1974).

The medial orbital wall, although thin, receives support from the ethmoidal air cell walls, and as a result, it requires greater force to fracture it (Biesman *et al.*, 1996). Nevertheless, fewer air cells with large lamina papyracea between septa will increase the likelihood of medial fractures (Song *et al.*, 2009). Differences in fracture site due to racial anatomical differences have been reported in the literature (Gittinger *et al.*, 1986; de Silva and Rose, 2011): de Silva and Rose (2011) suggested that an increase frequency of medial wall fracture in comparison with orbital floor fracture in African-Caribbean race might be attributed to the strength of the orbital floor. The authors reported, however, that the incidence of blow-out fractures in relation to the site was similar between Caucasian and Asian (Chinese) in their sample. Interestingly, Asian studies on blow-out fractures, Korean in particular, reported a comparable or even higher incidence of medial blow-out fractures compared with floor fractures (Jin *et al.*, 2007; Chi *et al.*, 2009; Song *et al.*, 2009).

The incidence of combined fractures might be related to the anatomical continuation of the floor to medial wall. Our study showed no significant influence of fracture site on preoperative and postoperative diplopia, ocular motility scores or subjective outcome in relation to diplopia. This finding agrees with Brucoli et al (2011) who found that the site of the fracture had no influence on postoperative diplopia.

The incidence of left side fractures is higher in our sample. Bilateral involvement was reported in only one case within the surgical category. In fact there are few reported cases with bilateral blow-out fractures in the literature, only 5 cases with bilateral blow-out fracture published in the last decade (Takehiro *et al.*, 2000; Swinson *et al.*, 2004; Agir *et al.*, 2005).

The difference between the incidences of right and left sided injury is more evident in surgical group. Biesman *et al* (1996) also reported higher incidence of left side fractures (57%), while Hossal and beatty (2002) reported almost the same level of incidence for both sides. Given that the majority of cases were assaults, it could be postulated that a blow from a right fist would results in a left sided injury, and the unequal distribution observed in our study. However, the difference between two sides in other causes of injury still favours the left side, although in closer percentages of occurrence. Literature review did not show any explanation about the reason for differences in frequency of occurrence between both sides, and whether it was related to the cause of trauma, assault in particular.

Diplopia was the most common clinical finding compared to other clinical features in our study. This concurs with other studies Helveston (1977), France (1994) (78%), Biesman *et al* (1996) (86%), Jones *et al* (1997) (67%), Shantha *et al* (2000) (70.3%), Hosal and Beatty (2002) (83%). Enophthalmos, on the other hand, had a low recorded incidence compared to other orbital features. The incidence of enophthalmos in previous studies was higher, ranging from 30.6 to 62% (Jayamanne and Igillie, 1995). Hosal and Beatty (2002) in their series of 42 patients with pure blow-out fractures in orbital floor and medial wall found that 30.9% of the patients have enophthalmos greater than 2 mm. One of the reasons for the low reported incidence of enophthalmos in our study is that it is often a late rather than immediate complication of fracture. In this study, the majority of fractures, even with no significant diplopia, were repaired early, which may have prevented subsequent enophthalmos.

There is general consensus on the low incidence of ocular injuries in blow-out fractures (Jones and Evans, 1967; Lerman, 1970; Biesman *et al.*, 1996). In our sample, the reported ophthalmic injuries were less common compared to other complications. Low incidence of ocular injuries in blow-out fractures has been explained by the occurrence fracture itself, with pneumatisation of maxillary sinus acting as a protective mechanism (Kellman and Schmidt, 2009).

3.5.3 Orthoptic findings

Ocular motility disturbances in orbital injuries are frequently assessed using a Hess chart. The reliance of orbital trauma studies on Hess charts only, makes diplopia recording subjective and often difficult to evaluate (Sveinsson, 1973). It has been noticed that diplopia and ocular motility disturbances, as terms, have been used frequently in orbital fracture studies interchangeably (Egbert *et al.*, 2000; Koide *et al.*, 2003; Lee *et al.*, 2005), whereas, more correctly defined, diplopia represents the clinical manifestation of an ocular motility disturbance.

Assessment of diplopia using a Goldman Perimeter (BSV test) is generally considered the 'gold standard' for diplopia assessment (Holmes *et al.*, 2005). Despite this, the Goldman Perimeter has not been used consistently in clinical studies (Evans and Fenton, 1971; Dulley and Fells, 1974; Harris *et al.*, 1998; Lee *et al.*, 2005). Recently, there is increasing evidence in the literature which favours its use as a routine procedure, using both weighted (Sullivan template) and unweighted scoring, as it is simple tool and allows numerical analysis for both orbital and visual functions. Banks *et al* (2010) stated the advantages of BSV over Hess charts, suggesting the latter to be difficult to present numerically.

The UFOF has been validated in ocular motility measurement in thyroid eye disease patients (Steel *et al.*, 1995; Gerling *et al.*, 1997; Haggerty *et al.*, 2005), although its use for orbital trauma patients has not been reported. Despite the popularity of Hess charts in ocular motility assessment in orbital fractures, UFOF appears to have some advantages. UFOF identifies the affected muscle/muscle groups as the result of trauma. Also it may aid in determining whether the muscle has been restricted or is under activated, for example as a result of direct injury with no actual incarceration. UFOF can provide the examiner with a reliable comparative numerical measurement using the contra lateral muscle/muscles in the unaffected side.

From our study, it would appear that patients with low BSV (<60%) may benefit more from surgery than higher BSV categories. However, low BSV score alone cannot be considered as a criterion for surgical intervention. The main reason behind this is that we do not have sufficient data for low BSV score in the conservative group to compare the level of improvement. Only 4 cases (in the conservative group) lie within lower and middle BSV score categories in which their preoperative and postoperative BSV scores were available. T-test statistics, however, suggest that these 4 cases did not have significant change in their BSV scores.

Nevertheless, it might be suggested that BSV score thresholds could be used to help in the choice of treatment. Patients with BSV scores > 80% (n=13) did not benefit from surgery in term of BSV level. On the other hand patients with BSV score >80% (n=11) whom were conservatively managed showed significant improvement.

3.5.4 CT scan findings

According to our results, orbital fat herniation was the most common reported level of orbital tissue herniation. This agrees with the finding of Sleep *et al* (2007) where periorbital fat involvement was reported in most of the cases.

Entrapment of extraocular muscle was reported in only two cases in the retrospective sample, agreeing with what has been reported in the literature. The literature suggests that entrapment of extraocular muscles is uncommon in adult blow-out fractures (Egbert *et al.*, 2000; Sosuke *et al.*, 2001; Arnoldi and Mattheu, 2004; Gosse *et al.*, 2009).

To the best of our knowledge, the influence of orbital tissue herniation level on diplopia (BSV score) and ocular motility (UFOF score) has not previously been reported. Our data showed that orbital tissue herniation has a negative influence on both ocular motility and diplopia. Correlation coefficient values, however, indicate that this influence is not a considerable one. Thus factors other than tissue herniation are likely to play an important role in ocular motility problems in blow-out fractures. Koornneef (1982) stated that incarceration of orbital tissue is not responsible for severe ocular motility problems, rather a dysfunction of the entire motility apparatus in the fracture region. Furthermore, it is not only the mechanical displacement that should be considered, but also the extent of the related muscle injury (Harris *et al.*, 1998).

Weak correlation between tissue herniation and diplopia could be also explained by the fact that diplopia and ocular motility scores in "fat herniation" cases, which constitute about half of the cases, were not significantly different from the "no tissue herniation" level.

The level of tissue herniation was not previously included within the criteria for surgical management. However, the absence of significant difference in diplopia and ocular motility scores between "no tissue herniation" and "orbital fat herniation" levels, as well as the fact that cases with orbital fat herniation have almost the same prevalence in both management groups, raises the question of the value of surgical management in cases with orbital fat herniation alone.

The fact that most of the cases (60%) with low BSV were reported to have orbital muscle herniation might suggest that orbital muscle involvement in the fracture defect could be an important factor in lowering BSV score in blow-out fracture cases. Higashino *et al* (2011) in their case series found that all cases had diplopia when the herniation of the inferior rectus muscle into the maxillary sinus was half or more of its section.

It is generally agreed that coronal CT is the first choice of view in orbital blow-out fractures (Rowe-Jones *et al.*, 1993; Courtney *et al.*, 2000) with its superiority in diagnosis of medial wall fractures over axial CT (Santos *et al.*, 2007). In our case series we found that Coronal CT scans were available in all cases, while sagittal views were used in 30 cases. This affected the ability to accurately determine defect size in our sample. However, in this study the mean size of orbital floor fractures was 0.83 cm^2 (minimum 0.141 cm^2 and maximum 4.2 cm^2), which was similar to the mean size of medial wall fractures observed, 0.84 cm^2. However, the maximum size for the medial wall was less, 2.35 cm^2. The size of medial wall fractures in our sample is less than in Jin *et al*'s (2000) sample, which might be attributed to the racial anatomical differences.

The relationship between fracture size and ocular motility has received little attention in previous studies, predominantly being reported in relation to enophthalmos. In this study, no statistically significant relationship was found between the size of orbital fracture and the level of orbital tissue prolapse in the fracture line. The size of the fracture also had no apparent influence on either preoperative BSV or UFOF. This finding disagrees with Sveinsson (1973) who believed that the extent of diplopia depends on the size of the fracture.

3.5.5 Surgical findings

Surgical indications for blow-out fracture usually target diplopia, enophthalmos, or large size defects which may result in late enophthalmos (Turnbull *et al.*, 2007). The criteria for diplopia as an indication for surgery as suggested in the literature are subjective. Conversely, enophthalmos, as an indication, has objective management criteria.

It has been found that the percentage of surgically managed patients is slightly higher than Dully and Fells (1975), Putterman (1991) and Gosse *et al* (2009) who reported about half of their cases with surgical intervention. However, Higashino *et al* (2011) reported that the majority of their sample (89 out of 106 cases) were managed conservatively, demonstrating the subjective nature of the decision to intervene.

In this sample, the subjective surgical indications were persistent diplopia, with the presence of a fracture confirmed on CT, and/or enophthalmos. Large asymptomatic defects were treated on the basis that enophthalmos could be expected as a sequelae. A baseline orthoptic examination taken preoperatively has generally been used to support the clinical decision rather than determining the need for surgery. The presence of 'persistent diplopia', is frequently stated as a criteria for surgical management of blow-out fractures of the orbit (Cole *et al.*, 2007; Gosse *et al.*, 2009), along with terms like "diplopia not resolving significantly within the first 10 days" (Fells, 1975); "visually handicapping diplopia" (Putterman, 1977); "disabling diplopia" (Biesman *et al.*, 1996); "clinically significant diplopia" (Hosal and Beatty, 2002); "diplopia persists for several days of observation" (Yano *et al.*, 2009) are subjective terms.

In keeping with general agreement, the optimum time window for surgical intervention in this sample was considered to be 2 weeks, (Dulley and Fells, 1974; Hawes and Dortzbach, 1983; Hartstein and Roper-Hall, 2000; Hosal and Beatty, 2002; Hamedani *et al.*, 2007). Catone *et al* (1988) in their review of 18 cases based on the generally followed protocol on blow out fractures of the orbit (surgery within 2 weeks for persistent diplopia) found that 85% of the cases had complete resolution of diplopia. Accordingly, they recommended this protocol for orbital blow out fracture management.

Half of the cases in this sample were treated within 7 days, which reflects the tendency for early management of this injury. This also might be related to the early clinical presentation of these cases. More than 75% of blow-out fracture cases were presented within the 7 days of the injury and 13% of cases within the 2nd week of injury.

Despite the fact that the mean postoperative diplopia score (BSV2) decreases with increasing time to surgery, surgical timing was not found as a highly influential factor on either BSV2 or subjective outcome in relation to diplopia. Jin *et al* (2007) also found that surgical timing was not statistically related to postoperative diplopia. They considered surgical timing to be crucial in cases with trapdoor fractures with extraocular muscle entrapment, which is uncommon in adult blow-out fractures (de Man *et al.*, 1991). Shin *et al* (2011) reviewed 233 cases with non-trapdoor blow-out fractures which were surgically treated for diplopia; 195 cases were treated within 2 weeks and 38 cases treated between 15-30 days. They did not find a significant difference between the two groups in terms of diplopia outcome. However, this disagrees with Hossal and Beatty (2002) who found a significant relationship between timing of surgery and postoperative diplopia.

Nevertheless, our data showed that cases which had been treated more than one month from injury (10% of the cases) did not show significant improvement in BSV score. Putterman (1991) believes that orbital surgery after 5 weeks was unlikely improve ocular motility disturbances. For such cases he advised extraocular muscle surgery.

Surgical technique for orbital blow-out fracture also raises debate (Courtney *et al.*, 2000). Among such issues is surgical approach (Stassen and Kerawala, 2007), which is frequently a matter of personal preference or related to previous teaching. In a questionnaire sent to 256 surgeons in UK, Courtney *et al* (2000) found that the infraorbital and the subciliary approaches were most commonly used (78%), transconjunctival and mid-lower lid incisions were not common.

In this sample subciliary approach dominated the surgical group, providing adequate, rapid access to the fracture (Holtmann *et al.*, 1981; Yano *et al.*, 2009; Salgarelli *et al.*, 2010). However, our data showed that approach is not an influential factor on BSV2, BSV score improvement or subjective diplopia outcome.

This study data showed no significant relation between the size of the fracture defect and the choice of implant material. This is an interesting finding, because anecdotally surgeons usually decide the choice of implant material upon the size of the defect, which agrees with Fries (1994) and Camuzard *et al* (1988). This could be attributed to the discrepancy between CT scan findings and surgeon's judgment. It is possible, also, to assume that CT scan in some cases might suggest small defects, while surgical manipulation might reveal that the bony margin of the defect might not be strong enough to support small implant material. In our sample small defects were generally repaired with silastic sheet, as seen in almost half of the fractures. This alloplast is readily available, of low cost, is easily shaped and is of adequate rigidity (Fries, 1994).

Our data showed that bone graft cases showed higher postoperative mean BSV score followed by silastic implant then titanium mesh. The difference, however, between mean BSV scores in the 3 types lies within 10% of BSV score. This might explain why there was no significant relationship between the choice of implant material and postoperative BSV score. Prowse *et al* (2010), in a 12 year comparative retrospective study of 81 patients, compared silicone implant material (silastic implant) and non-silicone implant materials including bone and cartilage grafts, resorbable and titanium implant materials. The comparison was based on the surgical outcome in relation to post-operative diplopia, pain, abnormal eye position, infection, palpable implant and numbness. They found a lower incidence of these complications with silicone materials compared to non-silicone materials. However, they reported 4 cases out of 58 silicone material cases where silastic implant required surgical removal, with extrusion in 3 cases. Displacement during active globe movement especially in large unfixed implants has been previously reported (Potter and Ellis, 2004). Infection was seen in the fourth case; silastic implants frequently produce an avascular implant-capsule interface, with the potential for infection of the peri-implant space. Morrison *et al* (1995) did not believed that it is ideal implant material as they had to remove the implant material in 13% of the cases because of infection, migration and worsening of diplopia. In our sample, 3 out of 48 cases treated with silastic implant, in which the silastic sheets were removed, with one case the silastic sheet was replaced with bone graft for persistent diplopia.

Titanium mesh also used widely in our sample. According the department policy titanium mesh was preferred in larger size fracture. Gear *et al* (2002) stated that Titanium mesh is usually recommended for large orbital defects because of its good functional outcome and low risk of infection. However, there was no significant relation between CT fracture size and the choice of implant material.

Despite the fact that autologous bone graft is considered as the gold standard for repair of orbital floor defect (Baino, 2011), it was seldom used in this sample. This might be related to its complications: donor site morbidity; resorption with potential enophthalmos and difficulty of contouring (Morrison *et al.*, 1995; Gear *et al.*, 2002) making bone less likely to be chosen for small isolated orbital fractures with minimal possibility of enophthalmos (Fries, 1994).

The trend for blow-out fracture repair in this sample reflects the tendency for use of alloplastic material over autogenous bone graft. The size of the defects, wide availability of implant material with the continual improvement in their characteristics, time factor and avoidance of donor site morbidity might be the reasons in the material choice.

Overall, our data showed that choice of implant materials was not an influential factor in postoperative BSV and final outcome in relation to diplopia.

3.5.6 The surgical outcome

The primary aim of surgery is considered to be to release incarcerated tissue to restore ocular motility. Inadequate surgical release, especially in posterior fractures has been suggested to influence motility outcome (Noorden and Campos, 2002; Kim *et al.*, 2003; Ochs, 2004). However, surgery itself does not address direct extraocular muscle injury (Iliff *et al.*, 1999), indeed, muscle injury may occur during surgical manipulation (Kugelberg *et al.*, 1998). Sleep *et al* (2007) believe that this type of injury in blow-out fractures is usually associated with delayed recovery, with over 6 months persistent diplopia being not uncommon.

About 77% of the surgically managed patients had a postoperative diplopia score (BSV2) within the moderate and high BSV score categories, 60-100%. Dulley and Fells (1974) considered 60-90% BSV as satisfactory surgical outcome. Apart from Dully and Fells, there are no quantifiable criteria as to what could be considered as successful outcome of surgery, with most of the available literature using subjective terms to describe the level of postoperative ocular motility (Putterman, 1977; Hosal and Beatty, 2002; Gosse *et al.*, 2009).

The subjective outcome in relation to diplopia can be divided into two categories; favourable outcome category which includes “asymptomatic” and “not aware or concerned by diplopia” groups and unfavourable category which include “symptomatic” and ‘requiring further measures” groups. The “symptomatic” category includes cases which did achieve improvement after surgery in terms of diplopia, but, they were reported with variable degrees of residual diplopia. Our data showed that patients with low BSV scores are more likely to be at risk of an unfavourable diplopia outcome. The mean postoperative BSV for this group was still around the upper limit of low BSV score category. This might explain why this group of patients reported as symptomatic. This finding is in keeping with Lee *et al* (2005), who stated that postsurgical ocular motility disturbances usually persist if the extraocular motility was significantly affected by the trauma.

The fact that about 50% of surgically treated cases, for whom follow up data was available, were still complaining of postoperative diplopia in variable degrees is comparable with (Kuttenberger *et al.*, 2008) and agrees with the notion of Harris (2006) about the ocular motility outcome in surgical cases of blow-out fractures being less than ideal. Unfortunately, this data is compromised by the number of surgically managed patients for whom no postoperative data is available (n= 88).

Our data has shown that preoperative and postoperative BSV scores relate to subjective outcome in relation to diplopia. The lower the BSV1 score the less favourable outcome will be, despite the fact that cases with low BSV category achieve better score improvement compared to those in the high BSV category. This fact reflects that BSV score improvement itself does not relate to subjective diplopia outcome. This has been statistically confirmed. The absence of significant relation between BSV improvement and subjective diplopia outcome might be explained by the fact cases with low BSV1 could still end up with a moderate BSV2, despite the obvious improvement in BSV score. Whereas, cases high BSV1 with little improvement could still have high BSV2.

In addition, BSV improvement measures the difference between preoperative BSV score and first postoperative BSV score. Diplopia, in some cases, improves gradually over time. The other factor might be that patient appreciation to the outcome might not be influenced by physical improvement in diplopia score. It could reflect that there are certain levels of improvement which have not been found by patient as significant, and some patients might still find it uncomfortable having residual diplopia postoperatively.

Despite the fact that tissue herniation level has no statistical influence on the subjective diplopia outcome categories, our data showed that cases with orbital muscle herniation are more likely to have an unfavourable diplopia outcome. Harris *et al* (1998) believe that the more tissue involved in the fracture, the more likely to there is to be ocular muscle injury, which negatively affects the motility outcome. Indeed, it may be tissue injury rather than tissue herniation that is important in diplopia arising from orbital fractures.

3.5.7 Follow-up time

Published studies to date have presented variable postoperative follow-up periods. A comprehensive literature review did not show a unified follow-up pattern for patients with blow-out fractures. The only reported follow-up protocol for blow-out fracture was by Orgel (1971), who adopted a monthly follow up period. In this retrospective sample the time between follow-up visits did not follow a particular time, and was primarily dictated by the patient's progress. Our data showed the significant influence of preoperative diplopia score on both follow up time and number of follow up visits. The higher preoperative BSV score the shorter follow up time and the less number of follow-up visits.

It is interesting to find that the relation between BSV score improvement with follow-up time is positive relation. This might be explained by the fact that higher improvements reflect lower initial BSV scores. Patients with lower per-operative BSV scores might end up with moderate post-operative scores, the reason why some of these patients might still complain from certain degrees of double vision and, eventually, require more follow-up time.

This study data showed a wide range of follow-up time. The minimum follow-up period was 2 weeks postoperatively and the maximum was 13 months with mean of 4.5 months. Sleep *et al* (2007) reported (1-7) months as a time range for the resolution of postoperative diplopia, with mean of 4.4 months. Jin *et al* (2007) gave a range of follow up from 3 months to 4 years. Hosal and Beatty (2002) found that diplopia improved 1-4 weeks in 80% of their cases. The absence of a unified follow up period and timetable might be explained by the suggestion that ocular motility disturbances continue to improve for up to 9 months (Gosse *et al.*, 2009).

3.6 Summary

Through studying many possible factors that might influence ocular motility and diplopia, it was hoped to determine a more objective basis for management choice for blow-out fractures of the orbit. It is suggested that the use of quantifiable values for ocular motility and diplopia, along with the level of tissue herniation may be important factors to be considered in orbital blow out fractures.

Our data indicated that cases with BSV ≥ 80% may not benefit greatly from surgery, whilst possibly benefitting from initial conservative management. Unfortunately it has proved difficult to compare the diplopia score improvement in both management categories based on BSV values, as we do not have sufficient data from the conservative management side to compare.

In addition, it is difficult to define a diplopia score which distinguish between a motility deficit caused by direct tissue injury or due to tissue herniation in the fracture defect in this type of injury.

Despite the difficulty in determining BSV levels indicative of the need for surgical intervention, our data suggests that the benefit of surgery would be the most likely in cases with low BSV category (0-60%) and orbital muscle herniation. This has been based on 4 observations:

1- Orbital fat herniation does not seem to have significant influence on ocular motility and diplopia over no tissue herniation.
2- Both mean and median of BSV in cases with orbital muscle herniation fall within lower BSV category.
3- Most of the cases (69.2%) with low BSV category had orbital muscle herniation
4- Cases with lower BSV category benefit more from surgery compared to other BSV categories in terms of BSV improvement.

In terms of surgical timing it has been found that postoperative diplopia scores have a tendency to decrease with the increase in time to surgery. However, statistically, surgical timing does not significantly affect postoperative diplopia, if surgery is performed within 1 month of injury. However, these finding suggests that early surgical intervention is recommended when patient’s condition permits.

Our data showed that preoperative diplopia score correlates to postoperative diplopia, follow-up time, number of follow-up visits and subjective outcomes in relation to diplopia. This reflects the prognostic value of BSV score in cases with blow-out fractures of the orbit.

Chapter 4 Qualitative study

4.1 Introduction

Some researchers believe that the philosophical foundations of qualitative research were based on the work of twentieth century authors: Heidegger, Merleau-Ponty and Habermas. These foundations were applied by anthropologists, sociologists and recently by health care researchers (Berry *et al.*, 2006). Others believe that qualitative research can be linked back to the ideas of Immanuel Kant in his book (Critique of Pure Reason) published in 1781, when he proposed that "our knowledge of the world is based on 'understanding' which arise from thinking about what happens to us, not just simply from having had particular experience"; and Wilhelm Dilthey (1860s-70s) who emphasised the importance of 'understanding' and studying people's lived experience (Snape and Spencer, 2010).

The aim of qualitative research is to develop a concept that helps to understand a social phenomenon in natural setting rather than in an experimental setting (Pope and Mays, 1995). It seeks to explain and understand rather than quantify or predict. Qualitative studies seek to explore questions to which the answer is not known and predictions cannot be made. To achieve their aims qualitative studies use systematic purposive non-probabilistic sampling, not random sampling (Mays and Pope, 1995; Hartley and Muhit, 2003).

The success of both quantitative and qualitative research depends on the judgement and skill of the researchers and their ability to employ appropriate research methodology to answer a particular question. Researchers in both fields also have to ensure the rigour in which systematic and self-conscious research design, data collection and interpretation, are imperative requirements (Mays and Pope, 1995).

4.2 Aim of the study

To understand patients' experience of orbital blow-out fractures.

4.3 Objectives

To investigate the psychosocial impacts of orbital blow –out fractures on the patients.

To explore patients' adaptation to orbital blow-out fractures.

4.4 Study design/methodology

4.4.1 Qualitative methodologies and philosophical assumptions

The main difference between qualitative and quantitative research lies in the diversity of the philosophical backgrounds of the qualitative methodology. Qualitative methodology research is closely linked with the researcher's philosophical assumption (this will be explained further in the next paragrahphs). In quantitative research, methodology is a technical matter based on a unified philosophical background (Murphy *et al.*, 1998). Despite the fact that qualitative research has a range of approaches based on different belief backgrounds, the generic aim of most qualitative research methods is to develop conceptual understanding and theoretical explanation for the studied phenomenon (Ritchie and Lewis, 2004; Pope *et al.*, 2007).

In order to ensure an accurate qualitative study design, Ghezeljeh and Emami (2009) suggested that the researcher should state his/her philosophical view which defines his/her beliefs about truth (epistemology) and reality (ontology), which could be put under an overarching paradigm. The paradigm defines the ontological, epistemological and methodological approach adopted in a qualitative study (Ellett and Beausang, 2002).

Ontology is simply the study of being (Ghezeljeh and Emami, 2009). It is the nature of the world and what we know about it (Snape and Spencer, 2010). In other words, ontology asks the question; is there a reality outside what I think and believe?

Ontological stances lie between two extremes: realism and idealism. Realism suggests that there is an outside reality independent to our perception. The other extreme is idealism which states that there is no reality outside our belief and understanding and that reality is only what the researcher's perception provides him/her with. In between these positions lies subtle realism which acknowledges the presence of a reality but that this reality is symbiotic with, and exists through our interpretation. The ontological views could be exemplified by a movie (outside reality) which is seen by many spectators. Some of these spectators believe that what is happening in this movie is their reality. It is part of their everyday life (realism). Others find what is happening in this movie is just fiction and has no what so ever connection to their life (idealism). The last group of spectators believes what is happening in the movie is not their life, but they accept the fact that there are some events might actually happen or could have happened (subtle realism). Some of these spectators, however, differ in the extent of these events' existence and effect might bring to their life.

In this study I adopt the subtle realism view. It means that I acknowledge the presence of reality out there (the patient's reality). However, as I am a clinician, I recognize this influence on my interpretation of the patient's reality.

Epistemology is the (theory) nature of knowledge (Ghezeljeh and Emami, 2009). Epistemology, also, has two extreme positions. The first of these positions is positivism, which states that the world facts are independent of and unaffected by the researcher (Snape and Spencer, 2010). This position assumes that the social facts can be approached in the same way as the natural world, because human behaviour is governed by regularities that allow independent and objective social research (Ghezeljeh and Emami, 2009; Snape and Spencer, 2010).

The second epistemological position is interpretivism, which states that the social world and the researcher have a mutual influence on each other and that social facts and values are influenced by the researcher's perspective. Furthermore, since the social world is not governed by natural sciences rules, the methods of the natural sciences are not appropriate. Hence, the researcher has to explore the social world through the participants' perspective (Snape and Spencer, 2010). I have taken an interpretivist stance for the qualitative study.

Research should be governed by the phenomenon being investigated as opposed to rigid adherence to certain types of research (McEvoy, 2006). Otherwise any attempt to legislate the use of any method apart from the research question itself will violate the creativity and viability of scientific research (Colliver and Verhulst, 1996).

Methodology is the conceptual framework that governs the methods within a particular research (Nicholls, 2009a). Over the twentieth century different schools of qualitative research have emerged, such as: narrative, phenomenology, grounded theory, ethnography and case studies (Creswell, 2007). Each of these methodological schools is related to an overarching philosophy (Nicholls, 2009a).

Some researchers believe it is better in qualitative studies to avoid mixing between two methodological approaches, as this will violate the philosophical background of these approaches (Moore, 2009; Parahoo, 2009). However, there are some research methodologies have been recently suggested in the literature, in which no restrictions from existed methodologies, and the philosophical assumption is not explicitly expressed by the researcher, such as general inductive approach (Thomas, 2006) and framework approach (Ritchie and Lewis, 2004).

The methodology adopted in this study is a generic qualitative approach (Rapley, 2010; Snape and Spencer, 2010). This approach cuts across the most basic terms shared by different methodological approaches. This means the start with close inspection of particular dataset to discover certain themes, explore and explain the underlying pattern of the studied concepts and themes (Rapley, 2010). In this study, this approach aims to provide a wider and deeper understanding of the patients' experience with the types of injury under discussion. This understanding is hoped to help clinicians in providing more comprehensive approach in management of patients with blow-out fractures of the orbit.

4.4.2 Qualitative study design

Sampling

Qualitative research is concerned with the meaning that people give to the world, and it assumes that they are different in this instance. Hence it does not look for a sample of people who represent the population, but it looks for the sample which provides adequate insight (both depth and breadth) into people experience (Nicholls, 2009b). Qualitative research therefore employs a purposive sampling strategy, aiming to recruit participants who are likely to have different experiences.

Another type of non-probabilistic sampling employed in qualitative research is "Theoretical" sampling. This type of sampling is guided by the objective of explanation or theory development (Mays and Pope, 1995). In other words, the next participant recruitment is guided by data analysis for the need of theory development or extended exploration of various aspects of participants' experiences.

In the current study, a purposive, theoretical, maximum variation sample has been taken (n=21) to ensure breadth and depth of opinions and experiences. Sampling criteria were: preoperative, postoperative surgically managed patients; and conservatively managed patients; gender; age over18; severity of BSV; postoperative course (Figure 4-1and Table 4-3).

For the purpose of this study, patients were recruited from patients attending The Oral and Maxillofacial Department in Newcastle General Hospital with blow-out fractures of the orbit. Interviews were performed in one of the consulting rooms. The duration of interviews ranged from 30 to 50 minutes (Mean 37.6 minutes). These interviews were digitally recorded and transcribed verbatim.

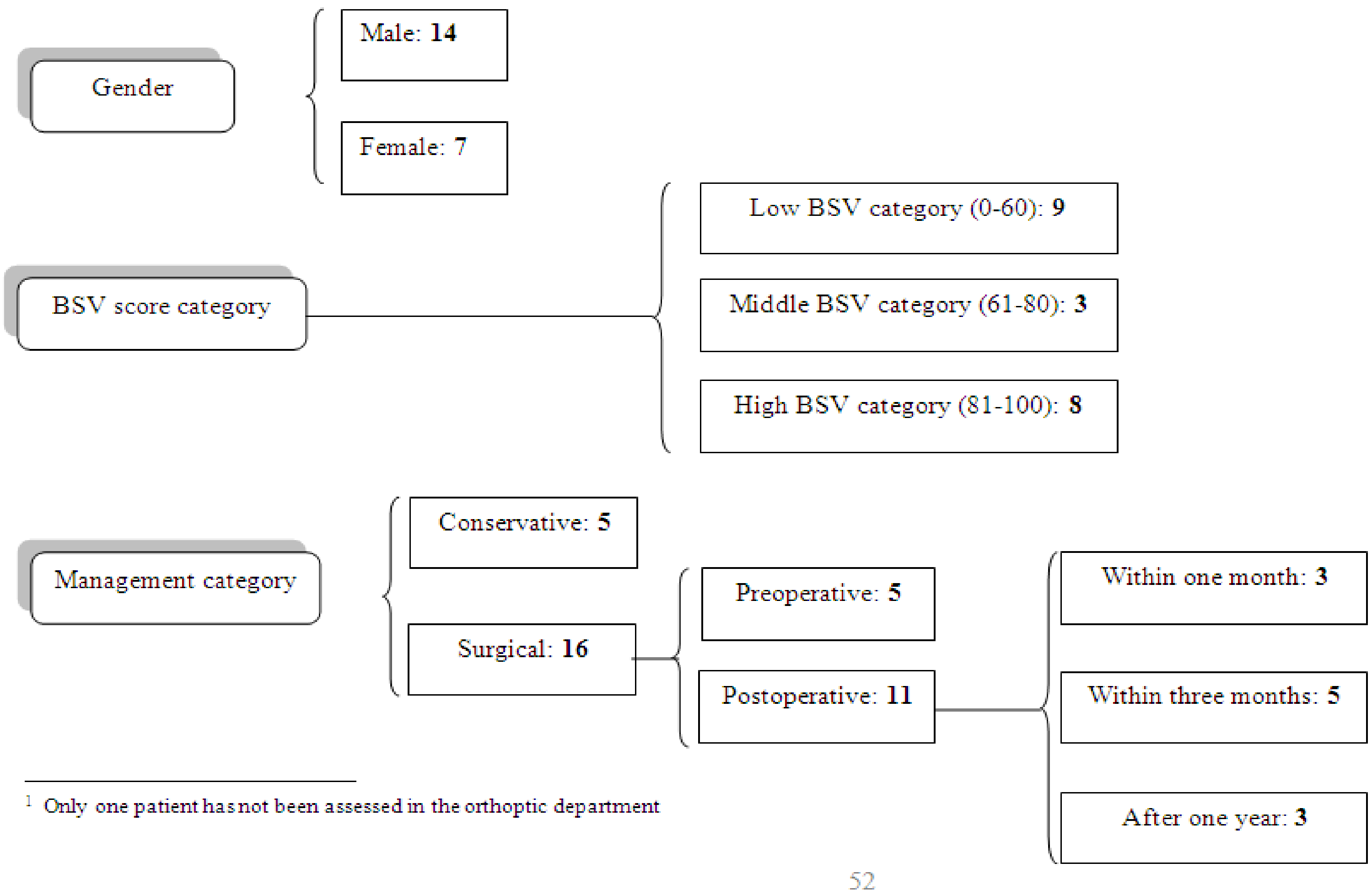


Figure 4-1 qualitative study sample

Data collection in qualitative research

There are 3 main methods of data collection in qualitative studies: observations, interviews and focus group discussions. Other less commonly used methods include the analysis of public or private documents, and e-mails (Hartley and Muhit, 2003).

Observation

In observational methods, the researcher systematically observes participants' behaviour in their natural environment. In this type of data collection, the researcher will be a participant in addition to being an observer (Pope and Mays, 1995). The assumption behind observation is that the best way to discover the real fact is by watching and listening. Observational data can be accrued from field notes, verbatim quotations, or from audio-visual recordings.

Focus groups

A focus group is a group of individuals selected to discuss their personal experience about the research topic (Powell and Single, 1996). It has been used to explore a wide range of health related issues (Wong, 2008). In focus group discussions participants are encouraged to talk to each other asking questions, exchanging ideas, experiences and points of view (Kitzinger, 1994). In this way a focus group is thought to encourage the research participants to explore relevant issues in the group, thereby meaning the participants conceptualise the research issue in the different forms of communication that people use in their daily lives as opposed to in the researcher's terms (Kitzinger, 1995).

For reasons of validity, logistical considerations, and time constraints, observation and focus groups were not used in this study. Both observation and focus group would not have been practical. It is difficult and sometimes intrusive to observe different patients in different places including potentially their home and work environment. If focus groups are not properly balanced it is possible that one more vociferous individual may speak for the rest of the group. In addition to this some of the issues to be discussed can be: a) personal, b) sensitive and/or litigious, and therefore focus groups were not appropriate. Semi-structured interviews were the preferred data collection method because they allow in-depth exploration of relevant issues with a singular individual.

Qualitative interviews

There are 3 types of interviews: Structured interviews, semi-structured interviews and in depth interviews. The structured interview has fixed standardised questions and the answers are from fixed choices. SF-36 is an example of structured interview (Britten, 1995). Qualitative interviews usually have more loose structure. Semi-structured interviews consist of open ended questions which define the areas to be explored as a beginning, and then it diverges for further details. Semi-structured interviews do not use a previously structured questionnaire, rather utilising a topic guide which, as the name suggests, provides guidance to the interviewer of the areas to cover during the discussion as opposed to a rigid structure of questions. In this way emergent themes can naturally be explored in the order in which they arise during the interview, thereby minimising the risk of “forcing” the interview.

In depth interviews are even less structured than semi-structured interviews. They begin with one or two questions and all the following questions will depend on what the interviewee will say. These questions aim to clarify and provide more depth understanding on the issue under question (Britten, 1995).

Qualitative interviews are essentially conversations with subjects which aim to understand the world from the subject’s perspective. They explore in depth the issues of concerns to the participant (Kvale, 2006). Qualitative interviews are widely used in exploratory health researches aim to study a range of patients’ concepts beliefs, attitudes and experiences (Murphy *et al.*, 1998).

In this study, the qualitative interview was used in preference to the focus group, for the reasons outlined previously. The privacy afforded by using interviews, we believe, allowed patients to be more open and willing to talk about what might be considered by some trauma patients as an embarrassing experience. Furthermore, individual interviews are performed in a natural setting at each participant’s appointment, and at the patient’s convenience.

The principle researcher conducted semi-structured interviews with the sample using a flexible evolving topic guide. The initial topic guide was informed by expert opinion and research examining strabismus and diplopia (Hatt *et al.*, 2007). Interviews were conducted until data saturation occurred, that is no new themes or ideas emerge from the data collected.

Data analysis

Data analysis in qualitative research differs from quantitative analysis. Quantitative research adopts a deductive reasoning approach (hypothesis testing). In qualitative studies an inductive approach is usually adopted, as data analysis process moves to hypothesis generation (Pope and Mays, 1995). Qualitative research, however, is not always about inductive reasoning, as it might involve both inductive and deductive approaches in various stages of the study (Snape and Spencer, 2010). Toward the end of qualitative studies, researchers try to direct their findings to state what is specific about the studied phenomenon, either through a single statement (grounded theory approach) or by trying to capture the essence of the meaning of the lived experience of the phenomenon studied (phenomenological approach).

In quantitative study the research aims to answer a specific question: does X differ from Y or is X related to Y. Whilst in qualitative research the researcher wants to know more about X,Y and Z. This understanding is achieved through open questions which require more than a one word answer. Furthermore, researchers in qualitative studies also use probes and prompts during the course of an interview. Probes are responsive questions used by the researcher to find out more about issues brought up by the interviewee. Prompts are questions which aim to raise other issues that might interest the researcher and have not been raised by the interviewer himself (Legard *et al.*, 2010).

In this study the approach was largely inductive as little is known about the factors that might influence patients' experiences of blow-out fractures of the orbit. During the process of data analysis we summarized the study findings towards two major concepts centred on the concepts of positive and negative influence.

Different methodological approaches adopt different analysis techniques (Richards and Morse, 2007; Spencer *et al.*, 2010). There are, however, common generic aspects in qualitative data analysis, such as "iterative concept", "coding" and "abstracting".

The iterative method is an important principle of qualitative research. It is early repetitive data analysis alongside data collection. This overlapping of collection and analysis helps to inform subsequent data collection through theoretical sampling, or through changing the interview/observation method used for data collection, to ensure the study explores for new data or disconfirming data for emerging themes (Pope *et al.*, 2000; Endacott, 2005).

The aim of coding is to move from unstructured data to sorting and providing structure to emergent themes from data. It is a way to simplify and focus on specific characteristics of the data. Coding is essential for data reporting (Endacott, 2005). Coding, however, is not merely labelling, in fact it leads the researcher from the data to ideas, and this will assist the researcher to abstract from the data (Richards and Morse, 2007).

Abstracting is the primary goal of qualitative research. It starts at the beginning of data collection. It is the way by which the researcher builds understanding from the data, as the researcher starts to conceptualize by transforming data from being individual instances through creation and exploration. That is why it is considered the most problematic part of the qualitative research (Richards and Morse, 2007).

In this study we used line by line coding and for the aim of data organisation we adopted framework approach, case by case and theme by theme (Table 4-2) (Ritchie *et al.*, 2004). The principles of constant comparative method (Glaser, 1965) were broadly employed to help produce an inductive and iterative analysis of the data.

Glaser (1965) divided constant comparative analysis into four stages: (1) comparison of incidents within a category, (2) integration of categories and their properties, (3) delimiting the theory which occurs at two levels: (1) the theory and (2) the original list of categories. In other word the theory solidifies as modifications of the theory become less even with the addition of new data as themes. The last stage of analysis is (4) writing the theory.

Constant comparison method simply means categorizing data in a list of coded themes, fitting each segment of the transcribed data in one of these coded themes (analytical categories). The chosen segments in each category (code) will be compared with others. This process is progressed through comparing between codes and categories. This comparison is continued with more data (Ghezeljeh and Emami, 2009).

To explain the analysis method used in this study further, it is helpful to use the generic steps defined by Creswell (2003) for qualitative data analysis. He believes that it is ideal to blend these steps with the specific design of the proposed study.

Step one: data organization and preparation: this involves interview transcription, and sorting data according to the sources of information

Step two: obtaining general sense of the information provided by the data. This includes looking for the general ideas; the general tones within the ideas; and having a general impression. In this study the first 3 interviews were reviewed searching for possible general trend or pattern provided by the data.

Step three: coding process or what could be called organization of the materials into blocks. These blocks were organized into categories and labeled, and this represents the start of the analytic process. In this study the coding process started after reviewing three interviews and continued to be refined throughout the data analysis.

Step four: generating a description, in which codes are used to generate a small number of (5-7) themes or categories (Table 4-1). These themes are analyzed for each case and across several cases or shaped into general description.

Themes	Codes
Physical complaint	Immediate complaint/ preoperative complaint Reaction toward injury Double vision
Opinion about medical and administrative procedures	A& E Administrative and professional medical procedures
Patient’s perception to various aspects of the injury	Description of the injury Knowledge of injury/ its influence Opinion of seriousness Concerns about injury Feeling protective about the injured eye Worries from surgery/concerns about surgery

	Aesthetic concerns Perception of outcome (physical) Perception of injury/outcome (psychological) Surgical decision Expectation from surgery
Direct influence of the injury	Effect of injury on daily life Influence on work Financial outcome
Social influence of the injury	Social life before/after surgery Family/friends role
Coping strategies	Psychological Physical

Table 4-1: General emergent themes and related codes after 3 interviews.

Step five: representing a description of themes mostly by using narrative passage to convey analysis findings. This could be achieved by describing the chronology of the event or discussing different themes relationship. This is usually accompanied by figures or tables as adjunct to the discussion process.

Step six: interpretation, which is the final step of data analysis. This could be termed as capturing the essence of the idea. Along with data analysis, a pattern was noticed (Figure 4-2). This pattern was developed into a theoretical construct to summarize the relationship between the analysis findings. Each developed version of the theoretical construct was tested against and informed by the newly emerged data (Strauss and Corbin, 1990).

All data in this thesis was independently examined by one of the supervisors (JD) and the emergent themes reviewed, discussed, revised, and agreed. The emergent themes and their representative data from the transcript has been organized and analysed using concurrent (iterative) method. Line by line coding was used to analyse the transcripts because it is the most intensive and productive manner in which to code (Strauss and Corbin, 1990).

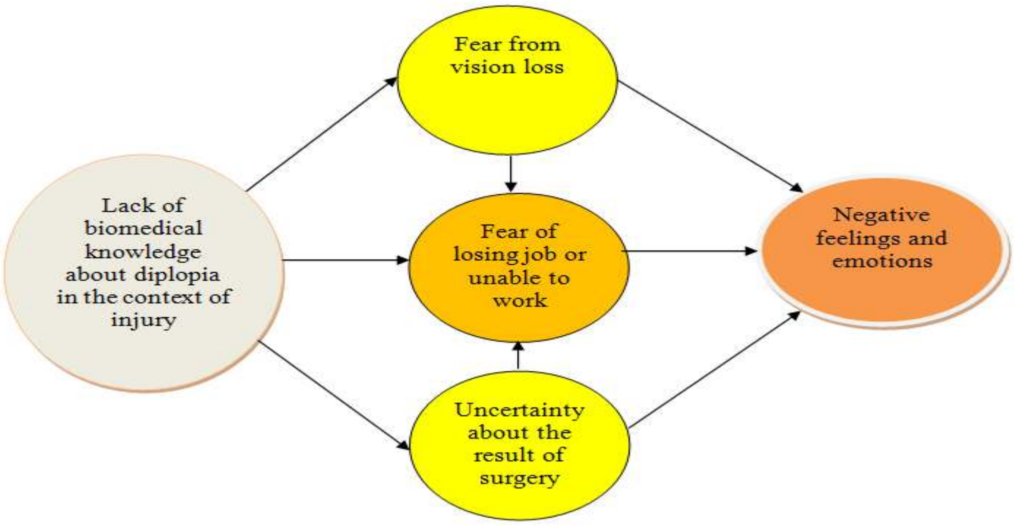


Figure 4-2 preliminary pattern

No.	Age and gender	double vision	effect of injury on daily life
case 1	female 24	1: 4 I had to cover this eye all the time before the surgery because my double vision I couldn't see a thing. 7:4 I couldn't see. I had to have this eye covered in order to be able to see anything because I had … there was no area in which I could see single vision if I had both eyes open. So … I tried the eye patch thing for about five seconds but I couldn't do it because all the sort of … it was all too painful around the eye for anything to touch it. And as I got used to my eye being closed I think I looked like I was kind of winking all the time 10:5 it looked like it was dead. For instance it had barely any movement at all.	12:5 Kind of between when it happened and when I had surgery it basically frustrated all of it. Yeah I couldn't … there was very little that I could do. 12: 15 it was frustrating and boring and I felt … I didn't sort of, obviously I did feel a bit cabin, a bit cabin, feverish a little bit sort of claustrophobic not being able to go out and do much. 13: 14 But I was able to do very … the sort of things that I would do inside, you know, and not think about it normally like go down the shops and get some stuff. Like my mum is extremely ill, she can't really get out of bed much, so running round just doing sort of errands helping her out, helping her out with the house and stuff.
case2	female 62	4: 11 I'd got a lot of double vision. I'd got one image above the other one. 6: 4 Before the operation. It was … it was fairly … I was fairly able to see at this end of the eye and it got very wide at the opposite end. Is that the right way round? One end was quite close together and the other end was very wide. I'm trying to think which way it was. I think it was this end probably that was very wide open. 8:10. My eye was starting to look as though it was sinking. As the swelling disappeared, the eye was sinking back more and you could see in the mirror that it was dropping. 24: 15 I think I was worried about it before the operation, whether it would … whether they'd be able to sort it out.	14:14 I seemed to want to sleep a lot. So I was sort of quite happy having 10 or 12 hours sleep at night and then dozing at times during the day. 5:2 I wasn't really doing a lot. I was meant to be going to Paris on the Friday. So we had to cancel that one. 5:5 … I didn't go out much because it was so cold. There was one point, I think at the weekend before the operation, I went out with my daughter, up to the Coast, and it looked sunny but as soon as we got out of the car the wind was biting into my face. So we didn't take a walk at that point. 16: 15 .... and I'm a lot more cautious driving … you know, sort of walking around, you know. A little bit more sort of anxious on stairways in say shops or escalators, that sort of thing. I want to hold on more.

Table 4-2 Extracted example from the framework data sheet (numbers refers to page and line numbers)

Patient code	Gender	Age	Cause of fracture	Pre or postop.	BSV score category	Injury and treatment course
1	Female	24	Fall	postop	Low	2 months
2	Female	62	Fall	postop	Low	2nd month
3	Male	40	Work accident	postop	High	2nd month
4	Male	48	Assault	preope	High	2 days before operation
5	Female	48	Fall	postop	Low	30 days postop
6	Male	45	Assault	postop.	Low	1 day postop
7	Male	32	Assault	preop	Middle	within 2 weeks of injury
8	Male	22	Assault	conservative	High	within 2 weeks of injury
9	Female	40	Assault	conservative	High	3 weeks after injury
10	Female	22	Kicked by accident	preop	High	6 weeks after injury
11	Male	26	Assault	preop	Low	one day preop
12	Male	21	Assault	postop	High	6 weeks postop
13	Male	19	Assault	preoperative	Middle	2 weeks post injury
14	Male	43	Assault	Conservative	High	5 days post injury

15	Male	24	Sport injury	Preoperative	Low	1 week after injury
16	Male	24	Assault	Conservative	High	2 weeks post injury
17	Male	19	Assault	Postoperative	Low	2 months post 2nd surgery
18	Female	75	Assault	Postoperative	High	18 months postoperative (from the retrospective group)
19	Male	55	Kicked by animal	Postoperative	Un assessed	3 weeks after surgery
20	Female	30	Assault	Postoperative	Low	4 weeks after surgery
21	Male	47	Assault	Postoperative	Low	More than one year after surgery

Table 4-3 Details of the qualitative study sample

4.5 Data and discussion

Blow-out fractures of the orbit may differ from other types of facial trauma. They are characterised by the highest incidence of diplopia, which may persist despite treatment. The influence of this long term diplopia and the presence of diplopia within the context of trauma may disable the patient in different ways to other facial trauma. The patient's experiences of blow-out fractures have not been explored in depth previously.

Consequently, little is known about the psychosocial impact on patients of blow-out fractures, which may, given the nature of the injury, be long lasting. These features accompany the patient throughout the journey from injury, and may continue beyond the "definitive" treatment.

This chapter attempts to explore and explain the patient's experience toward this type of orbital trauma, thereby providing an understanding of the impacts of this type of trauma which hopefully will lead to suggestions on how to improve management of these patients.

In this section it is intended to explain the following recurrent themes: patient's experience in Accident and Emergency Department (A&E), patient physician encounter, surgical concerns and making decision, time influence, surgical outcome and coping. These themes will be discussed in chronological event order from injury through to postoperative "recovery".

4.5.1 The patient's journey with blow-out fracture

Patients reported sustaining blow-out fractures as a result of an assault, fall or sports injury. The "shock" is the word used by patients to entitle the emotional impact of trauma.

"The only thing I noticed, the initial impact, well the shock at first" (Case 9, Female, Aged 40, Assault).

However, the patients found it difficult to describe their immediate reaction toward the incident. Normally, individuals assume a reasonably ordered and cohesive life path (Crossley, 2000). Trauma, by its nature, breaks this continuity (Tuval-Mashiach *et al.*, 2004), hence the experience of trauma will disrupt the somehow orderly sense of existence (Crossley, 2000). In fact trauma has the power to confuse ordinary forms of conception. Trauma seems to be incomprehensible and it belongs to another world because it is beyond the limits of our understanding (Belau, 2001).

Accordingly, it is not easy for a traumatised individual to describe the impact of trauma. This difficulty was more obvious in some patients, who at time of the interview, were still very affected by the incident and it was very current to them. Frank (1997a) pointed out that turning what is perceived as chaotic "unexpected" incident into verbal story requires the ability to distance yourself from the incident and therefore (re)gain the ability to reflect upon it.

It's a hard thing to try and put into words what was going through [my] head. It's more like I had the thought of why and the pain and trying to like not think about it at the same time. You know, it's like my mind was all over the place really. It's hard to focus on one thing." (Case 16, Male, Aged 24, Assault).

"I don't know, I don't know. I don't know if I was upset of the..., you know, thinking that I was in the wrong place at the wrong time, why did it happen to me, what's going to be the outcome of this." (Case 3, Male, Aged 40, Work injury).

It is suggested that trauma results in the loss of the sense of life's map and destination for the traumatised individual (Frank, 1997b). This might be the reason behind the fact that some patients start to question "Why". This questioning may reflect the patients' attempt to rationalise their senses towards what has happened, and also their attempt at rebuilding the coherence of their life stories (Crossley, 2000; Taieb *et al.*, 2010).

"Just like what's happened? Do you know what I mean? Why's it happened to me? You know, I hadn't done anything to provoke it or anything. It was just wrong place at the wrong time. (Case 16, Male, Aged 24, Assault).

This questioning may, however, not only demonstrate an attempt to make sense of what happened, but, also, might reflects the patient's feeling that the trauma is unjustified or unfair. For the patient, this incident should have not happened and there must been something wrong to make it happen.

"This just didn't need to happen. It didn't need to be there, I didn't need to have this worry. So that made us more frustrated and angry." (Case 9, Female, Aged 40, Assault).

In addition to the immediate psychological impact of this type of injury, the patients reported a degree of fear caused by the associated severe pain and alarming bleeding.

"I was just screaming and screaming and there was blood everywhere..... I was extremely frightened and confused and like didn't know what to do.... I could barely think because of the pain like it felt as if my whole head … someone had just punched it in, just punched right through it. So I couldn't really concentrate on anything else. .... I was too shocked and too frightened to think, you know, and to evaluate anything like that. I was in complete … I was

completely panicked.”..... “the pain was so, so immense because I wanted to try and fall asleep or sort of pass out, anything, because I was in so much pain.” (Case 1, Female, Aged 24, Fall).

Accident and Emergency Department (A&E)

Most of the patients in our sample reported attending the A&E department after the incident. What occurs in A&E has been described by some of the patients in a way that reflects their disappointment. In this study, interviewed patients reported their dissatisfaction with ineffective communication and waiting times. They believe that their suffering (pain and emotions) were underestimated by the clinicians.

“because the guy who was in A&E, I got the impression that he thought I was perhaps exaggerating maybe because I was in such a lot of shock he might have thought that I was perhaps over-doing how bad the pain was. So I didn’t get any proper … I got sort of Paracetamol and Ibuprofen. I didn’t get any sort of pain relief that did any good. … They just sent me away with a prescription for Paracetamol and Ibuprofen. … I was in agony for about three days until I came back to the hospital … because they saw the results of the x-ray and they were like ‘oh, okay we’re going to give you some, some kind of medicine’ and those couple of days were horrible”. (Case 1, Female, Aged 24, Fall).

“A&E didn’t really, well they just sent us away really. … They give us Ibuprofen and the Paracetamol...... It did take the edge off a little bit. It didn’t really help.” (Case 20, Female, Aged 30, Assault).

The emergency department (A&E) is considered to act as the gateway to treatment for the problem. As such, it should provide a satisfactory amount of care and information (Soleimanpour *et al.*, 2011). There are three important factors in relation to the services provided by an emergency department: staff skills, attitude and active communication (Trout *et al.*, 2000; Taylor and Benger, 2004), and waiting time (Taylor and Benger, 2004; Soleimanpour *et al.*, 2011).

Patient satisfaction can be achieved when the patient’s expectations for management have been met (Trout *et al.*, 2000). Taylor and Benger (2004) as they reviewed the literature on patient satisfaction in A&E, defined two factors that could influence patient satisfaction in A&E. These factors are: patient’s background, which includes age, sex, social status and illness severity; the quality of how patients are approached by A&E staff, which includes personal skills and the level of delivered information.

The immediate impact of injury needs to be considered alongside the physical complaint by the accident and emergency clinician. It has been suggested that lack of adequate attention towards patients' concerns in emergency department may result in poor patient satisfaction (Keller *et al.*, 2002). The brief patient-physician encounter, for some cases, in the emergency department might be one of the reasons for our sample's reported disappointment, as patients often complain about physicians who either poor listeners or are in a hurry (Barrier *et al.*, 2003). Rhodes (2004) found that, the physician-patient encounter in the academic emergency departments tends to be brief and lacking in important health information.

Ineffective or inadequate communication has been reported in other studies. Watt et al.(2005) did a focus group study on patients' expectations of emergency care and found that patients reported being frightened, anxious and in pain whilst in the emergency department. They also complained about the inadequacy of staff communication and explanations. They expected the staff to listen to their concerns and provide reassurance. Some participants expected frequent updates about the stages of their A&E visit including details on: investigation, treatment, and explanation for delays. What has been reported by some patients in this study echoes what has been reported in the study conducted by Watt *et al*. The following quote from our study shows the patient frustration of waiting in the emergency department for a long time without any idea for how long should he wait.

"I was like waiting nearly an hour before the [Oral and Maxillofacial S.H.O] come, then I waited nearly 45 minutes for my drops. And that was more frustrating than waiting all day. So it was more frustrating waiting because I'd been fixed and I was just waiting for the okay to go home. .. And it took nearly two hours, you know. ....But they were keep on saying "well we've got to get this signed form, we've got to..... If they'd have said "you were going to be here until seven" I would have just said "right, no problem, fair enough, I'll go and lie down again and go to sleep." (Case 14, Male, Aged 43, Assault).

The length of waiting time according to patients' expectation varies widely (Watt *et al.*, 2005). Some patients expect to be seen within one hour, others expect 3-6 hours, although a wait of 3-6 hours was the time period which had the most complaints (Watt *et al.*, 2005). One of the patients in this study accepted a 5 hour wait in the A&E department, because of the emotional support provided by the A&E staff, which helped console her and her pragmatism over the time of day and the day of the week she attended.

"And I was at the hospital quite a while, I would say maybe about five hours, and in them five hours.... And obviously you sit a long time because it's A&E, it was a Saturday night that, you know, you can accept that. But they were lovely to me. Because obviously apart from my injury it was an emotional upset what had happened, you know. And they were really, really

nice, really nice" (Case 9, Female, Aged 40, Assault).

Inaccurate medical information provided by the A&E, might heighten the patient's concern. The following quote shows the negative influence of misleading information provided by an A&E clinician about having more serious facial fractures. This made the patient more worried about his existing condition.

"The doctor from [hospital name] turned round and said that it wasn't a punch. There's no way it could have been done with a punch, this injury's been caused with a weapon. So, you know, you get all these visions in your head thinking someone's set about him with a bat, a bit of wood, a metal bar or what and when we came here it was like none of this was tallying with what [Doctor's name] said, it was just like total confusion. Just struggling to understand why one doctor could be saying this and then they're not saying it here." (Case 16, Male, Aged 24, Assault).

The emergency department, however, is a complex and stressful environment. That is why it has been described as a challenging (Keller *et al.*, 2002) and an interrupt-driven environment (Spencer *et al.*, 2002). Such environment may therefore inevitably interfere with patients' ability to understand their management (Engel *et al.*, 2009). Despite the fact that some patients might have some unrealistic expectations from emergency departments, such as providing all the required tests or answering all the questions they have, it is possible to improve A&E medical services to achieve better patient satisfaction. Improvement of A&E services is a multi-directional effort. It might be suggested one method to achieve higher patient satisfaction in A&E is to increase the medical staff awareness about the psychological impact of blow-out fracture and the concerns or worries that patients might have (Watt *et al.*, 2005). Sen et al.(2001) pointed out that greater appreciation of patients' problems at the time of initial trauma would improve the patient care over the longer term.

Our data and the literature also suggest that shortening the waiting time, at the same time as explaining the delays (Watt *et al.*, 2005; Soleimanpour *et al.*, 2011) might help improve psychosocial management of blow-out fractures' patients at initial presentation.

The patient-physician encounter in the consultant clinic

In the immediate period after the injury, some patients might be unaware how serious the injury was. For these patients getting punched in the face with the resultant swelling or black eye seemed to represent a mild soft tissue injury and an expected outcome after a blow. That is why some of these patients did not seek immediate medical attention. With the appearance of unexpected symptoms, like diplopia, or facts, like the possibility of orbital fracture, the patient will start to feel that it is not just a mild soft tissue injury, or even a broken nose. It therefore becomes apparent to the patient that it is more serious than expected.

"to hit and having a kick in the face, having a black eye, you don't expect so many complications of it, you know, to impact on you..... I was being told to man up, you've only got a black eye, you'll be fine. When I was actually walking around with a broken face. It was obviously a bit more complicated than I first thought it was just going to be." (Case 10, Female, Aged 22, Kicked by accident).

One of the emergent symptoms that makes the patient question the nature and the severity of the injury was the occurrence or presence of diplopia. When double vision is experienced, the patient starts to become concerned about the integrity of his/her vision. Patients with blow-out fractures seem to lack the biomedical knowledge about the nature of diplopia. They conceive diplopia, especially, complete double vision, as visual loss and a sign of eye damage. By using the term "eye" they are actually implying damage to the "globe" and subsequently their visual acuity (sight).

"I couldn't understand how I was getting double vision." (Case 13, Male, Aged 19, Assault).

"I'm unable to see and I wasn't sure … it was worry as well because I wasn't sure what's, you know I've been worrying until today, how they were going to fix it? Is it permanent?" (Case 11, Male, Aged 26, Assault).

"Obviously that's your worry initially, you know, have you really damaged the eye, the first concern was, you know, is my eyesight gone" (Case 4, Male, Aged 48, Assault).

The patients' concept of "sight damage" raises the issue of patient health literacy and the physician's role in overcoming the lack of patient's biomedical knowledge and ensuring they thoroughly understand the nature of their complaint. Health literacy has been defined as the ability to make informed decision within the health care settings (Kickbusch *et al.*, 2005). Despite the increased awareness of patient-physician communication and its role in improving patient's health literacy and the treatment outcome (Williams *et al.*, 2002; Barratt, 2008), it seems that there are still problems for some of the patients in our sample getting the medical information they require, or getting the information they require in a manner in which they can understand it.

"I was initially frightened but I wanted to know exactly what they would do. I'm terrible for that, I need to know everything. Even the horrible things, you know." (Case 9, Female, Aged 40, Assault).

As the patient moves from the urgent environment, or from A&E, to the elective and organised environment of a consultant clinic there still appears to be problems of understanding the nature of the injury. It seems that ineffective communication between the patient and the health care team is not the problem of the A&E department alone. The patient comes to the consultant clinic after an anxious waiting period with his/her concerns about the visual acuity.

"I was very, very bad. After the first couple of days when they opened [my eye] I couldn't read. Even [with] my glasses I couldn't see the chair. So it was really, really bad" (Case 4, Male, Aged 48, Assault).

Some of the patient reported visual concerns seem unrelated to the clinical facts dealt with by clinicians. Clinicians tend to deal with the clinical findings of this type of injury in a way that differs to how the patients perceive them (Table 4-4). For example, the surgeon considers what the patient believes as a probable vision loss as an eye movement problem related to presence of orbital fracture; and "sinking of the eye back into the head" as backward displacement of the eye ball (enophthalmos) due to an increase in orbital volume.

"...Because it is terrifying to know that my eye was sunk back in my head". (Case 1, Female, aged 24, Fall).

In other words, clinicians deal with this trauma and its related symptoms as a bony fracture that interferes with eyeball movement and/or position. Double vision and enophthalmos are signs of orbital wall fracture that warrant treatment, or as it is frequently mentioned in the literature as "correction". As a result of these different views and patient's lack of biomedical knowledge or understanding of the injury, patients might find it difficult to relate their complaint with the fact presented to them by the surgeon that they have an orbital fracture.

This difficulty is likely to relate to the use of medical terminology by health care providers as they communicate with patients who have inadequate health literacy and this acts as a barrier to them understanding their problems (Williams *et al.*, 2002).

"All I knew was that I had a fracture in my orbital floor and I didn't really know what that entailed" (Case 5, Female, Aged 48, Fall).

"*Patient: They told me that the tissue, as it heals, can cause obstruction. So therefore as time goes by, the way in which the tissue heals, could actually cause a problem.*

Interviewer: Obstruction of what?

Patient: Of the eye… Eye movement, the vision, I don't know, I'm not a medic ....

You're hearing all this medical stuff but you don't really understand what it's all about." (Case 10, Female, Aged 22, Kicked by accident).

Another aspect of ineffective patient-physician communication is the technical-medical form of the relationship usually adopted in patient-physician encounter, which can constrain the development of engaging patient-physician communication (Hall and Roter, 2007). The usual professional conversation in clinical setting, which is mainly based on specific clinical facts, might limit the physician's ability to address effectively the patients' concerns. Clinicians might be unaware, sometimes, of the psychological attitude of patients with this type of trauma, which might influence the patients' reaction toward the symptoms and the clinical facts provided by the clinician.

Although it is difficult to understand the complex relationship between trauma and its short or long term psychological outcome (Carlson, 1997a), our data shows that patients with blow out fractures experience distress and frustration at least in the short term. This distress and frustration is related to the trauma itself and to its disabling consequences.

"it was frustrating and boring and I felt … I didn't sort of, obviously I did feel a bit cabin, a bit cabin, feverish a little bit sort of claustrophobic" (Case 1, Female, Aged 24, Fall).

"Quite distressing" (Case 5, Female, Aged 48, Fall).

"Oh terrible, it was just like … it made us feel sick. Like you'd been on a Waltzer or something like that, it just makes you feel dizzy, it's a horrible feeling. When I'm trying to drive and that, well I couldn't drive for … I think it was about two weeks I couldn't drive for. Trying to focus, especially in the dark, I couldn't see a thing." (Case 20, Female, Aged 30, Assault).

"I was grumpy; I was sort of short tempered, because of the state of my eye. So my family felt that they were being sort of picked on by us. Because I was sort of on a, you know, me eye's gone … there was frustration. It was a major frustration for us". (Case 3, Male, Aged 40, Work injury).

Facial trauma is known to be accompanied by distressing psychological reactions, with post-traumatic stress disorder being the most prevalent condition (Bisson *et al.*, 1997; Levine *et al.*, 2005; Roccia *et al.*, 2005; Auerbach *et al.*, 2008). Auerbach *et al* (2008) found that the psychological influence of facial trauma was related more to the patient's subjective appraisal than to the objective severity of the trauma and this would seem to be apparent in our data also. The following quote for one of participants expressed her frustration from her condition, despite the fact that she had 90% single vision.

"They told me that 90% of my vision is good, 10% is double. I couldn't believe it was 10%. I thought I've got double vision, it's not … I'm not used to that. You know, it feels a lot worse to me because I'm trying to function in my job, day to day, and I can tell. And then to say 'well you've got 10% double vision'. Is like 'well how many people have double vision and feel like that's okay?' Because I don't feel that that's okay (Case 10, Female, Aged 22, Kicked by accident).

It is important for health care providers to consider psychological sequelae of trauma (Shetty *et al.*, 2003) as it has been shown that most individuals suffering from trauma report losing self-related positive feelings, positive self-image and worth (Horn, 2009). This would help to partly explain some of the participants' description of the trauma as a negative life changing experience. It is suggested that such post-traumatic psychological effects may also have an influence on patient's compliance with treatment and recovery from the physical effect of injury (Hull *et al.*, 2003).

In addition to the influence of trauma itself, the impact of trauma related disability should also be considered. As disabling illnesses have wide influence on patient's life (Falvo, 2005), a patient with disability may experience depression and other distressing feelings (Mechanic, 1995).

"Quite distressing. I get a lot of vertigo because of it. If I left eye open, the damaged eye open, I tend to lose balance and have to grab something or I'll fall. Walking's quite difficult. Gauging distances and, you know, the height of objects, stairs, going downstairs and things is quite difficult. Doing what I call 'the horse walk' where you lift your leg really high to sort of gauge where my step is. Getting through doorways and things like that." (Case 5, Female, Aged 48, Fall).

The distress and frustration exhibited in the above quote related to the diplopia experienced could be further exacerbated by fear and uncertainty over perceived visual impairment and eye damage. Fear or anger is usual immediate post trauma response (Carlson, 1997c), but it seems in our sample that diplopia related visual impairment tends to direct patient fears and concerns towards possible loss of vision (not routinely probable in this injury) and this impairs their ability to continue with their lives in a normal manner.

"What's happened? Am I going to go blind on this side?" (Case 21, Male, Aged 47, Assault).

"The hardship from it is, you know, just thinking to yourself will your sight ever come back?

Will I be cross-eyed for the rest of my life" (Case 3, Male, Aged 40, Work injury).

"[I was] Scared, because you don't realise how important your eyesight is until you've not got it to the level that you're used to having it at. ..... I felt that my vision wouldn't come back". (Case 10, Female, Aged 22, Kicked by accident).

"A bit shocked, a bit frightened, I don't know, it's hard to say really. I haven't really suffered an injury like that before......I wasn't expecting it.......the fact obviously that it had swollen up so quick........ I wasn't expecting, just from a blow to the face for so much trauma." (Case 12, Male, Aged 21, Assault).

The impairment and activity limitations of orbital blow-out fractures seem mainly related to diplopia. Patients perceive diplopia as a serious visual problem (visual impairment). The following quotes show the extent of this impairment as perceived by patients. As a result of visual impairment caused by diplopia, patients perceive diplopia as a serious visual problem.

"It looked like [my eye] was dead because it had barely any movement at all." (Case 1, Female, Aged 24).

"It was like my head was turned to the side. But my head was straight, you know, I was looking right enough. And I was like bamboozled by it." (Case 3, Male, aged 40, work injury).

It is clear from the previous quotes, how this perceived visual impairment can interfere with wide range of essential daily activities. This might be the reason why patients sometimes find it difficult to explain the influence diplopia on their lives.

"It's difficult for anyone to imagine what it's like and how it affects you. Because it's almost like, you know, we all have, in our lifetime, some time or another have a cold, have a cough, a headache, vomiting, diarrhoea or whatever. But until you get really double vision, it's very difficult to imagine what it's like and also how it affects you. So … and I think that's the difficulty is trying to get some of the understanding how double vision would affect you." (Case 7, Male, Aged 32, Assault).

It has quite far-reaching implications, shall we say. It's not just 'oh that's double vision'. (Case 5, Female, Aged 48, Fall).

"I'm unable to see and I wasn't sure … Am I going to be able to drive? Will I be able to work? Will I be able to play football? ... Obviously I can't work, can't drive." (Case 11, Male, Aged 26 Assault).

Any impairment has direct causative effects on the daily activity limitations that constitute disability (Thomas, 2004b). The level of visual impairment caused by diplopia seem to be no exception, as patients with complete double vision (no single vision in any fields of gaze) report more limitation problems than patients with a degree of single vision. Complete diplopia was reported to have negative influence on their confidence during performing usual daily activities.

"I was quite nervous about walking around the house. Just from the point of view of having fallen over thinking 'am I going to fall again?' You know, that kind of sort of … it saps your confidence really doesn't it" (Case 2, Female, Aged 62, Fall).

It has been found that diplopia caused by other health problems (strabismus[3]) has broad scope of both functional and psychological effects (Beauchamp *et al.*, 2003; Beauchamp *et al.*, 2005a; Beauchamp *et al.*, 2005b). Coulter *et al* (2007) found that impaired vision as a result of diplopia was strongly related to various negative feelings such as anxiety, depression, confusion, fatigue, anger and tension. There are also a preponderance of non-specific negative findings reported by patients suffering from strabismus induced diplopia (Hatt *et al.*, 2007) which would also seem to be the case in our data:

"A lot of worry…. [it is] just a nightmare." (Case 11, Male, Aged 26, Assault).

"I still haven't properly cried until now, because I don't know why I should but I know I should." (Case 16, Male, Aged 24, Assault).

Clinical findings associated with blow-out fractures such as diplopia and enophthalmos, for the patient, are not merely symptoms of orbital wall fracture. The patient deals with each of these signs as a problem in his/her eye. They are not just functional or aesthetic problems, for the patient, these problems mean that there is damage in the eye. Similarly, when the patient has surgical emphysema[4], the patient tends to relate it to a problem within his eye.

Periorbital surgical emphysema is a benign, transient collection of air associated with small orbital fractures communicating with the paranasal sinuses.

"I blew my nose and that was when my eye blew up and that was when I realised something wasn't right, you know, something … this isn't normal. To blow your nose and your eye to sort of blow up." "When I blow my nose the air's come through into my eye. And then I was thinking 'oh my goodness this might be a bit more serious than I think'. You know. (Case 9, Female, Aged 40, Assault).

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[3] Strabismus is an eye disorder, could be congenital or acquired, due to defective eye movement of the affected eye; as a result they do not look at the same object at the same time thereby often causing diplopia. Rowe F, editor (2000b). Incomitant Strabismus: Blackwell Science Ltd.

"Every time I moved me eyes there was pain there. It felt like me eyes wanted to pop out of me face because like there was pressure or fluid down my eyes (bilateral emphysema).... every time I look round they're hurting." (Case 16, Male, Aged 24, Assault).

The previous findings show the heavy burden caused by the blow-out fracture and its disabling consequences. The physical and psychological effects of blow-out fractures may distract the patient and thereby negatively influence his ability to pay full attention as the medical information delivered (Rosenzweig *et al.*, 1997). This will then interfere with the patients' ability to relate the pure clinical facts provided by the physician with their complaint.

If the health care provider is unaware of the extent of the burden felt by the patient, he/she might think that informing the patient about what has actually happened according to the clinical and radiographical findings will give the patient the ability to understand the problem. In fact on the basis of our data the contrary might be true, as the patients seem unable to link these clinical and radiological findings with their concerns and therefore the use of visual aids in the form of CT scans or radiographs may only serve to further confuse some patients.

"They said it looks like you've got an orbital floor fracture where your eye's dropped. And I was just, you know, I thought it was … it's obviously serious, you know, it's not going to fix itself. And I was just … just felt vulnerable and obviously, you know, I can't see properly. So it was a bit of a shock really." (Case 11, Male, Aged 26, Assault).

"I don't know. I just thought that's where the punch it isn't cracked there. That's why I'm getting it but I don't know … maybe I should have said 'well what bone does that do for my eye'." (Case 14, Male, Aged 43, Assault).

"They said there's a nerve that goes round there that controls this, goes through the floor or something. I don't know, I'm not sure.

I said 'I'm not going to lose my teeth then am I?'

They said 'no." (Case 20, Female, Aged 30, Assault).

This patient-physician miscommunication might exacerbate the patient's fear and uncertainty about the injury. The feeling of uncertainty is commonplace in the medical literature, especially in chronic illnesses (Bury, 1982; Goodman *et al.*, 2005; Nettleton, 2009; Durham *et al.*, 2010). Durham *et al* (2010) found with TMDs sufferers uncertainty is a common problem, because of the inadequate explanation they had received for their symptoms and this negatively impacted on their lives.

Living in uncertainty about health condition can also lead the patient to have thoughts that may be unrelated to their medical conditions. Goodman *et al* (2005) interviewed 36 patients with systemic lupus erythmatosus. They found that the lack of previous knowledge about their condition resulted in wrong initial idea about it. Accordingly this led to wildly distorted cognitive and emotional representations of the disease. Representation of a disease, according to Leventhal (1983), is the common sense definition of threatening health condition.

The data in this study demonstrate that the uncertainty caused by the lack of adequate knowledge about the nature of diplopia leads the patient believe that he has a potential loss of vision, whilst actually, he/she does not.

It appears that the biomedical focus for clinician differs from the patient focus. This difference in the perspectives is clearly explained by a health care professional in our sample experienced a blow-out fracture. This experience gave him/her a better insight about the way patients feel and how to be approached more effectively.

"In a patient's point of view it might be different because they don't have the background that I have, they don't have the understanding perhaps of the anatomy and physiology that I have. And it would be quite difficult for people to try and get round in their head about why and what and approaches and things like that....... I find that I'm telling patients things so that they are aware of what we are doing and you just kind of go like that. And I'm not entirely convinced that they actually understand what I'm saying. But, you know, I do try and explain and I do encourage them to ask questions and if they don't understand I will explain it again. And it does help, I think, it does help. But also I think it's a learning experience for me to become a patient and understanding some of the disease process as well. And to be a bit more understanding about how, in a receiver point of view, about how I could do better as a doctor." (Case 7, Male, Aged 32, Assault).

It seems that inadequate health literacy and an unclear medical message are not the only reasons for ineffective communication. Sometimes patients are just unable to be clear about their concerns. It is suggested that patients, in general, are unable describe what happened and what they feel exactly in patient physician encounter (Szolovits, 1995; Hall and Roter, 2007). A patient wrote down his questions, before the consultant clinic appointment, with the help of his medical student girlfriend in the way shown in the following quote.

"Will I get the feeling back in my upper left cheek? If so, how long? What's the likelihood of the double vision remaining after surgery? If the double vision stays, what can be done to fix it? How the operation will be done? Any complications/ risks/side effects? Will I have a scar?

How long will it take for full recovery for me to get back to work, drive and play sport? When can I go to the gym? Play football? Will I have to wear eye protection when playing football in the future? Do you have any eye patches? Any permanent damage to the eye? That's my … they're my questions." (Case 11, Male, aged 26, assault).

The quote shows, the patient put his real concerns, according to the interview, in the bottom of the list as he mentioned (*that's my ...they're my questions*). First the patient put his partner's questions. The sensory disturbance and the terms "risks" and "side effects" were not mentioned by the patient during the interview, they were, however, written in the first part of his list.

Some patients find it difficult to explain why they did not express their concerns to the surgeon about their eyes. Some patients share their real concerns with the close family members instead.

"No, I've told me parents. They told us what would happen and I felt quite relieved but I never mentioned anything to [the surgeon]…. I'm not sure [why] I guess I just … maybe I just want to get it over with. I don't know......... I should be optimistic." (Case 13, Male, Aged 19, Assault).

Hall and Roter (2007) explained this difficulty by suggesting that distressed patient either physically or mentally is not keen to be engaged in social conversation, or they are reluctant to appear inappropriate or foolish. The previous quote might provide another reason, as this patient seems to be afraid to express his visual concerns as he feels it may affect his ability to be positive and optimistic. This reflects the hidden fear of the possibility he might be confronted with some facts, which he might be unable to deal with, if he expresses his real concerns.

Another reason for patients to withhold their real concerns may be related to the nature of the medical interview itself. A closed questioning pattern is often followed in the medical interview and this therefore sets a narrow field for the patient potentially preventing most of the patients to elaborate (Hall and Roter, 2007). It might, also, give the patient the impression that questions asked further by the clinician are those that are of primary importance in the management. This epistemological authority may make the patient reluctant to speak with the physician about his real concerns.

"Interviewer: why didn't you tell the surgeon about your concerns?

Patient: "because I feel it's probably … well, for a starter, she's a doctor, she asks the *questions that she needs to know about" (Case 15, Male, Aged 24, Sport).*

The previous quote reflects the parentalistic model of patient physician communication, where the patient is submissive to the physician's professional authority (Charles *et al.*, 1999). This creates a professional distance, which may make the patient feel it is inappropriate to mention what he considers are personal worries and concerns to the surgeon, especially when the patient believes that knowledge of the surgeon about these issues will not change the treatment plan and the surgeon knows how to deal with condition in the suitable way.

"she's here to deal with the injury and to know about the wider picture is not her concern because I'm sure she sees quite a few of these every day, a lot of them a week". "I didn't see why … why [expressing my concerns] would it help [the surgeon] do his job any better? Because, at the end of the day he still has to treat it in the same fashion no matter what the circumstances." (Case 15, Male, Aged 24, Sport).

The previous quotes were taken from a rugby player who found it more suitable to discuss his professional concerns, about his ability to continue playing for the coming season, with the team's physician. His view was that the team physician, will in turn, discuss the matter with the surgeon. The patient believes that the club doctor will be more able to convey his concerns to the surgeon, as the patient trusts that the team physician is better equipped to understand his situation. The level of relationship between the team doctor and the patient makes the patient feel that he can discuss these issues with the club doctor. The patient considers the club doctor a suitable advocate in order to close the communication gap between him and the surgeon.

"Well in a sports environment is a different environment. So I want to go talk to my doctor with the Club who … obviously who does understand my situation and he can … so then when he talks to the surgeon"… "[the team doctor] has a greater understanding of my injury, doesn't have the emotional ties that is going through me that would affect such a decision, but he does have the knowledge. So he could say 'well that is a risk worth taking' so I'd rather go … whereas obviously the surgeon would be more likely just saying 'that we need to get this eye back properly' because he needs the 100% strike rate". (Case 15, Male, Aged 24, Sport).

Given the difficulties apparent in our data, clinicians treating blow-out fractures of the orbit may need to reconsider the way in which they approach and communicate with patients. The literature suggest that it is better to encourage patients first, allowing them to express their concerns and ascertain what they actually know about their condition (Travaline *et al.*, 2005; Hall and Roter, 2007; Zandbelt *et al.*, 2007). Improving patient-physician communication in this manner can improve emotional, psychological and physical outcome (Travaline *et al.*, 2005). Furthermore, encouraging patients to ask questions about their health condition helps to reduces patient anxiety and such compassionate communication will not only strengthen the therapeutic relationship, but it will also help the patient to cope (Travaline *et al.*, 2005). One of the methods to engage patients in consultations is the use of both verbal and nonverbal encouragement (Zandbelt *et al.*, 2007). Encouraging patients in this manner may increase consultation time, but is also likely to establish realistic expectations of outcome and improve psychosocial outcome.

Another method to improve patient physician communication is to shift from physician-centred interview to patient-centred interview. In the commonly adopted physician-centred model, the interview follows a biomedical pattern. Whereas, patient-centred interview allows the physician to be more attentive to patients expression and concerns (Barrier *et al.*, 2003). Within the data there were reports, though not many, suggesting that some clinicians were potentially adopting this approach.

"I was really pleased and that I knew then there was nothing wrong with the eye itself. Because I'd spoke to the consultant and that and he told us it's the eye socket that's fractured and the muscle." (Case 14, Male, Aged 43, Assault).

One of the other approaches used to explain the injury to patients evident in our data was showing either conventional X-ray or CT scan images. Showing the CT image to some patients with blow-out fractures can, however, be a distracting rather than informative during the consultation, although for others within our sample there was value in seeing CT scan image in that it provide a better understanding of the injury.

"I maybe should have asked them questions [related to my eye]. I don't know why. I'm very surprised because I normally ask a lot of questions. May be I was more fascinated with the machine [CT scan machine] wasn't I? It's so good. Yeah. I was more interested in that. Oh there's my cracked bone and what's that there? I was just amazed at the machine really." (Case 14, Male, Aged 43, Assault).

"It just explained it better. Seeing it for myself rather than having a doctor explain to us. Because I don't really understand medical terms, first they explained in medical terms and then they showed you the CT scan, so, I understood a lot better." (Case 20, Female, Aged 30, Assault).

Not all patients in our sample seemed to need or want the same level of detail of information about their condition and treatment.

"[name of the surgeon] took me through the CT scans quite comprehensively, until then I didn't really fully understand what it was. I didn't realise … I knew that there'd been a fracture and that the eye had sunken. I didn't know, I didn't know about the look." (Case 1, age 24, Female, Fall).

"On the x-ray it just looked like a crack out of the floor. I looked at it and I had a little fracture crack on that side. I looked at it and I thought that's my bones, what are they doing smashing my bones in. Do you know what I mean?" (Case 6, Male, Aged 45, Assault).

Surgical concerns and making decision

Patients' visual concerns experienced in this type of injury are clearly expressed in some of the patients' notion of having surgery in their "eye" and being uncertain about the outcome of surgery in terms of its effect on visual acuity. These concerns around vision made the decision to undergo surgery more difficult, especially if they had only mild impairment or when surgery was indicated to prevent possible enophthalmos.

"I don't know how I feel about that. But it's a worry getting to have an operation obviously it is, particularly on your eye (Case 4, Male, Aged 48, Assault).

"Well obviously I'm thinking – operation – what for, how bad it is? What's happened to my eye?" (Case 21, Male, Aged 47, Assault).

Effective physician-patient communication is an important prerequisite for patient to be able to become involved in making a choice about treatment options (Coulter *et al.*, 2008; Kripalani *et al.*, 2010). Increasing the patient's involvement in decision making (shared decision making) also tends to improve outcome (Edwards and Elwyn, 2005).

Uncertainty about treatment decisions within health care systems is not unusual (Cayton, 2004; Coulter and Ellins, 2005). The available evidence suggests that true shared decision-making is not widely adopted. It seems that crucial information is inadequately expressed by physicians and is equally as poorly comprehended by patients (Coulter and Ellins, 2005). Charles (1999) identified 3 models of decision making in health care: paternalistic model, informed model and shared model. In the paternalistic model the patient submits to the professional authority of the physician, whereas the informed model involves a partnership between physician and patient. Here the physician provides the patient all the suitable information about the possible treatment options regarding the advantages and disadvantages, to enable the patient to make an informed treatment decision. In a shared model, on the other hand, there is shared agreement through all stages of decision-making and treatment decisions. Charles (1999) pointed out that in the real clinical world, the decision making process is some form of a hybrid model, due to the complexity and dynamicity of human nature and the personal nature of patient doctor relationship.

Our data, however, showed that patients either followed, or were led to follow, the paternalistic model. The reason behind this seems to be environmentally driven. Before entering the consultant clinic, the patient waits anxiously to find answers to his concerns and s/he believes that the surgeon will help him to clear their concerns. This makes the patient prepared to accept the epistemological authority of the surgeon. The patient already believes that surgeons are the experts.

"I'm just confident with my consultant. He seemed very good, very professional, told me exactly what's going on" (Case 8, Male, Aged 22, Assault).

This belief might be further supported by the unclear message patients report receiving from the clinician, as this also leads them to simply accept the surgeon's authority.

It has been suggested that that the medical interview has 3 main functions: 1) gathering information; 2) building relationships; 3) patient education (Cohen-Cole, 1990). Data gathered in this study raises the question about the effectiveness of the third function. The third function aims to provide the patient information about the diagnosis, the course of treatment and prognosis. This function of the medical interview is critical to the course of care. For the patient to be involved in the treatment decision, s/he has to understand what the surgeon is suggesting about diagnosis, treatment, and prognosis (Lipkin, 1996). Accurate understanding is necessary for informed consent in order that the patient can select the best treatment option for them (Lipkin, 1996; Sowden *et al.*, 2001). In clinical reality, however, it is difficult to separate between these three functions, as they are intertwined (Cohen-Cole, 1990). Accordingly, inability to achieve adequate patient education may be the result of inadequate relationship building and information gathering.

From our data it would seem that the problem with patient-surgeon communication starts with data gathering stage. In other words with the way the medical interview starts. Medical interviewing textbooks, usually, refer to the importance of the chief complaint. The surgeon's job is to focus on this complaint with little attention paid to other contexts of patient's experience associated with his or her health problem. The surgeon follows a certain course in the interview, through closed ended questions, to reach the diagnosis. This form of questioning, which is common in medical interviews, represents an interruptive conversation pattern. This interruptive interview pattern may not allow some patients to express their thoughts. Subsequently, an inappropriate message might be provided by the surgeon during sharing the diagnostic information (Frankel, 2000). This can be seen in our sample from some patients' mixed emotions and reactions to the possibility of surgery. Surgery might be a difficult decision for a patient to make, but it would appear in our data that the consultation does not help to calm down patient's fears and concerns, especially about surgery "in eye".

"When I got back here I was worried. You don't know what's going to happen. You don't know whether you should … you know; whether an operation is what you want or whether it isn't what you want?".... "I don't like people being in my eyes." (Case 10, Female, Aged 22, Kicked by accident).

"Because it's my eye and you only get one set of eyes, I'm a little bit concerned about that." (Case 14, Male, Aged 43, Assault).

"[It's worrying because] something wrong with the bone around your eye. I think the big thing that worried me was like again my sight and this operation." (Case 9, Female, Aged 40, Assault).

Despite the fact that it might be unclear how the surgery improves their vision, some patients did show more enthusiasm for surgery, and it seems to be that one of the influencing factors is the degree of diplopia. Patients who subjectively perceive a more disabling degree of diplopia appear more frustrated about their visual acuity and they hope that surgery will improve their vision.

"[The decision] was very, very easy. …. I was like 'please do something, I'm not scared of surgery, I'm not scared of needles, I'm not scared …'. I was like 'if there's something that can be done, please do it." (Case1, Female, Aged 24, Fall).

"I couldn't wait to get into hospital, get the surgery done." (Case 5, Female, Aged 48, Fall)

On the other hand, patients who have less concerns about double vision, seem to be more anxious about undergoing surgery. Patients with single vision in the primary central position seem to think that surgery might not be a preferable option. The other reason for this might be the prospect of having time off work, especially if the patient feels that he can continue to work even with certain degree of double vision.

"I was very down, it was a bit of a surprise and you don't expect your eyes to require big surgery or things like that when I can see fine, I don't have any double vision now. So I did feel a bit down, I don't know, I don't know about the emotion, down or whether that's a good emotion, I'm not sure. When [they] showed me the CT Scan it just confirmed my feelings of

dread that I might have to think about my future in terms of [job] and how it's going to affect my job really. I didn't really think about my health, I thought about that." (Case 15, Male, Aged 24, Sport injury).

Similarly, the patient's expectation (hopes) from surgery seems to be driven by the patient's concern about his/her vision and it would be reassuring for them to know the that surgery will overcome the visual difficulty and be able to carry on with their lives.

"Well I suppose I had hopes that, you know, that the vision would be, you know, good enough to drive and … I suppose is what I'm saying. And, you know, to go back to my work." (Case 2, Female, Aged 62, Fall).

"Well I don't expect but I'm hopeful of getting my double vision sorted and that my eyes line up and I can focus with both eyes rather than just one separate eye." (Case 11, Male, Aged 26, Assault).

"[I hope] just for the double vision to go really. Yeah, that would improve my … the quality of my sight, back to being sort of like the sight that I had or like just the double vision gone sort of thing, you know." (Case 6, Male, Aged 45, Assault).

Time

Time and its influence on blow-out fracture management have been extensively discussed in the literature. This discussion tends to be centred on the surgical timing of repair in relation to achieving the most optimal surgical outcome for both postoperative diplopia and enophthalmos (Haddad, 2003; Ogata *et al.*, 2004; Jaquiery *et al.*, 2007; Kuttenberger *et al.*, 2008).

Time for patients has a different emphasis. In the data, time before operation seems to have negative influence on the patient's condition, especially if the patient does not know if he/she is going to lose his/her vision or will become diplopic for the rest of his life.

"A lot of worry, a lot of anxiousness, And I know it can't be helped but you've got to wait, you've got to wait for results. You've got to wait for CT scan results, I know that. But waiting's awful when you're waiting for something that you're worried about." (Case 9, Female, Aged 40, Assault).

"Scared, because you don't realise how important your eyesight is until you've not got it to the level that you're used to having it at. .... I felt that my vision wouldn't come back......Because I had double vision for a whole week. So imagine having it for a whole week. Every day you get up and it's still not getting any better. And then, you know, and you think 'oh I wonder what's gone on here' and 'will I get it back?'. (Case 10, Female, Aged 22, Assault).

This might explain why early management has a reported positive influence in our data. The following quote shows how the patient is overwhelmed by the speed his condition has been dealt with.

"I went to the [hospital name] on Monday and the [hospital name] then said 'yeah you've got a problem with your eye we're going to send you straight down [hospital name]. Within an hour I was in, cat-scanned, seen, sent directly to see the chap that I needed ... the surgeon. The surgeon said that I was coming straight in for surgery. Did I have anything planned? I said 'no'. He says 'good, because you would have to cancel it'. A really nice chap. Within the time of coming in to the hospital, getting me clothes off and into bed I was down in surgery within 20/30 minutes. (Case 3, Male, Aged 40, Work injury).

However, the presentation of some cases might be delayed. For some patients this type of injury might not be alarming at the beginning and does not warrant immediate medical consultation. The data showed that some of the patients might go to the A&E department after period of time with the appearance of unexpected symptoms like surgical emphysema.

The surgical outcome

Patient's concerns about vision influence his/her perception on the surgery outcome. Patients understandably consider the return of some/ any single vision as an encouraging outcome, even with a certain degree of persisting peripheral diplopia. As the patient feels that he/she can see, the patient can regain his confidence.

"And it just ... within 6-8 days it's just righted itself massively. And I'm more than happy with the outcome of it. .... I feel a lot more confident, I feel myself again. You know, in fact I feel like bring on the world.... It's, I mean in my way of thinking now, if this is as good as it gets, I'm over the moon. You know? [Double vision is] so in the peripheral. It's not massively double, it's just if you look at your finger, yeah, it would be the end of that finger just slightly there." (Case 3, Male, aged 40, work injury).

"I was more worried about the straight ahead vision [Because that's the main focus] rather than the peripheral. ... If I can see straight ahead then obviously everything else that didn't really faze us as much." (Case 12, Male, Aged 21, Assault).

When the patients realise that they have regained some degree of single vision, they report becoming more confident that further improvement of their visual ability will occur.

"I've got double vision but I'm convinced that as time goes along and the swelling totally goes away I think my vision will come back. It may not be as good but it's still a damn sight better than losing it altogether. ... It's improving and it's more comfortable. You know I do get headaches but after what the gentleman just described to me it's because of the movement of my eye and the stretching of the muscles and so forth that's causing the headaches. And

now I know what the headaches are being caused by I'm not as concerned. (Case 19, Male, Aged 55, Kicked by animal).

From the clinical point of view, orbital volume change with subsequent enophthalmos represents a major indication for blow-out fracture surgery. Since patients, according to the department treatment policy, are usually treated within 2 weeks window from the injury, enophthalmos would not be quite evident for most of patients before undergoing surgery as enophthalmos might require more than 2 weeks being clinically evident (Charteris *et al.*, 1993; Whitehouse *et al.*, 1994).

Our data suggests that aesthetic concerns in the preoperative period are not as evident as in the postoperative period, because any pre surgical aesthetic concerns are overshadowed by the concerns around the visual ability.

"I just always worried about my sight, more than the fact of how I looked. Do you know what I mean? I was more worried about how I could see than how I would look. I mean obviously I don't want to look like a monster but, you know, I was more worried about my sight." (Case 9, Female, Aged 40, Assault).

"I need my eye" (case 10, Female, aged 22, kicked by accident).

"If I've got a scar I'm not going to enjoy that, but he said I might already have a little small scar from the cut. But he says when they operate they do an incision in one of the creases of me eye so you cannot really tell." (Case 13, Male, Aged 19, Assault).

The females in our sample placed more emphasis on any enophthalmos than male participants due to what they perceive as an alarming difference of appearance between their eyes.

"Especially pre-surgery, but to a certain extent post-surgery as well, it looked as though the whole eye and socket and everything had dropped. And – have you seen the film Quasimodo? You know, the Hunchback of Notre Dame? You know where he's always portrayed with one eye up … I started calling myself Quasi. I honestly felt as though this eye was half way down that cheek and that was horrendous. The first time I looked in the mirror I thought 'oh my god, no'. You know, that was a real shock." (Case 5, Female, Aged 48, Fall).

"Before surgery me eye was, I can't even remember now, but I think it was just slightly up. That didn't really bother us. The appearance side didn't really bother us." (Case 3, Male, Aged 40, Work injury).

Female patients with postoperative enophthalmos, even, if it was mild from the clinical perspective, might be disappointed from the outcome of the treatment. The following quote from a female participant illustrates this disappointment, despite the improvement in her double vision.

"Clearly, unless I've got enough make-up on and my glasses, I do not look like me, I don't look the same. But I did have quite a symmetrical face before. But now I don't. My eye is further back than it used to be. ... [My face] is not symmetrical anymore. ... (Case 1, Female, Aged 24, Fall).

The patient above found it difficult to accept the mild enophthalmos and the feeling of the implant material under her eye. The reason behind refusal of this mild enophthalmos might be related to the fact that changed body image is significantly related to self-esteem for females (Furnham *et al.*, 2002). This perceived sensitivity in body image is provoked by the widely accepted fact that the image of beauty, as portrayed by media, contemporary literature and marketing, has an idealised or unblemished look (Rankin and Borah, 2003). The high standards of female appearance presented by the media make it ever more difficult for girls and women to feel positive about their appearance (Gentile *et al.*, 2009).This consequently has the effect of diminishing the value of individuals who deviate from the presented "norm" in the media (Rankin and Borah, 2003). This patient had a high expectation from surgery. She has been told by some of her relatives who believed that they have some knowledge based on their experience, that the surgery would be straight forward and simple. This raises again the issue of the clear medical message to be conveyed to the patient. Inadequate communication between the patient and the surgeon through lack of, or incorrect nature of knowledge leave the patient with unrealistic expectations.

"My cousin had something similar and that it had been really straightforward. So I was under the impression … that it was really simple." (Case 1, Female, Aged 24, Fall).

Lack of perceived success can be moderated in some patients by the belief that the NHS cannot help them further. The notion that "*NHS have better things to do"* in the following quote reflects some patients' perception that there is a limit to what the NHS offer to them, thus their complaint does not deserve to be mentioned and they have to accept the level of what has been achieved.

But, to be honest, it's a waste of resources just for the sake of a tiny little bit of metal in my face for me to go through a whole procedure and use up, you know, I think the NHS have better things to do than make me feel a tiny little bit better about … a little bit of metal under my eye. It wouldn't improve the vision, it wouldn't improve … it wouldn't improve where my eye is so it's … that's it now. I've just got to work with what I've got now. … I think I should basically be grateful that I can see. Rather than complaining if it's ever so slightly different than before." (Case 1, Female, Aged 24, Fall).

"They've got better things to do. I thought they had better things to do than just worry about somebody like me. Not that I'm anybody. But I think it's not bad I can still see things and, you know, I mean not that I can see everything's good but it's not interfering too much with my life so I'm not really bothered." (Case 21, Male, Aged 47, Assault)

Taking into account the data presented thus far, it is possible to summarise patients' interpretations of the biomedical problem or concepts underlying a blowout fracture. This summary is shown in Table 4-4.

The biomedical clinical problem/concept	Patient's interpretation of biomedical clinical problem or concept
Blow-out fracture	Eye ball injury
Diplopia	Inability to see
Cause of diplopia	unable to understand most of the time
Enophthalmos	Sinking of the eye in the head
Infra orbital paraesthesia	Loosening/knocked teeth
Surgery	Surgery in the eye
Surgical concerns over diplopia	Ability to see, ability to return to work, ability to drive
Aesthetic concerns over enophthalmos	Mostly not apparent (frequently enophthalmos is not very evident preoperatively)
Postoperative complications/findings (enophthalmos, lymphatic oedema, noticeable surgical scar)	Not expected

Table 4-4: Patient and physician perspective about blow out fractures of the orbit.

4.5.2 The influence of blow-out fracture on everyday life

Blow-out fractures of the orbit appear to have a wide-ranging impact on patients' lives, in terms of: impairment, activity limitations and participation restrictions. Impairment refers to a problem in body function because of significant alteration or loss. Activity limitation means the difficulties encountered by the individual in performing activities due to their impairment. Participation restrictions are the problems experienced by an individual when involved in life situations (WHO, 2002).

Visual impairment associated with diplopia was reported by our sample to have a major impact on their ability to work. It is difficult for some patients to pursue their jobs, whether manual or administrative, as most jobs require adequate degree of single vision.

"[As far as job concerned] your sight's everything. (Case 16, Male, Aged 24, Assault).

"[I had to leave the work] I was kitchen porter, washing dishes. But like going in the morning it was the lights in the kitchen, the lights in the kitchen are a certain spectrum. So like I would be alright for like an hour but after that like I was trying to focus all the time, trying to bring me eyesight back into focus when I was at work. I just couldn't do it. It felt as though me head was going to split in two because it was just constant all day trying to focus, trying to bring things back into focus....I think it was roughly about two to three weeks later for me job I had to leave because I just couldn't focus on anything, couldn't really wash dishes properly because I couldn't focus on them good enough, so I just had to leave." (Case 13, Male, Aged 19, Assault).

Consequently, the work environment can become a stressful environment. The patient starts to feel worried about his ability to continue in employment. For patients who find themselves successful in their jobs, the possibility of losing the job is a difficult prospect to consider. Some patients were not confident that they will keep their jobs because they are not sure that they will have reasonable degree of vision in the future.

"I work in a construction site. Things like climbing ladders, you know working at height it's … I don't know how it would affect me. .... Well my career is very important to me at the minute, because obviously I have a successful career." (Case 11, Male, Aged 26, Assault).

Loss of job due to trauma related physical limitations has been found to be associated with higher psychological morbidity (Mason *et al.*, 2002). It negatively influences patient's feeling of accomplishment, control, independence, pride, and self-worth. These negative feelings, with the related financial burdens, might contribute to depressive symptoms (Horn, 2009).

Diplopia also interferes to varying degrees on patients' ability to drive. DVLA medical questionnaire 'V1', states that an individual must be able to control or suppress the double vision to be eligible for driving (DVLA, 2010). However, it seems that patients differ in their approach to driving, regardless of their ability to deal with diplopia.

"I'm a lot more cautious driving". (Case 2, Female, Aged 68, Fall).

"I'm not driving yet because I'm concerned … if I was driving straight forward I'd be fine, but if I come to a Junction and I look both ways and then I get double vision then it's not going to be safe for me to drive. So I'm not driving until the double vision gets a lot, lot better." (Case 19, Male, Aged 55, Kicked by animal).

"I was driving up the A1 and my eye, my bad eye, fixed onto the bridge, but this eye had fixed on to a car. And trying to get your brain round that. That was very, very scary. So I pulled over, phoned my wife up and she came and got us...... Oh that's it. Just when you drive home tonight, stop, go cross-eyed, and you'll see what I see. Honestly, it's frightening. Even when you're driving along the motorway and you go cross-eyed and you see the double brick, woah. ...... Really the hardest point was night time driving, because to see that many lights it's just like woah. It's like going down Blackpool Illuminations. Oh it was wow" (Case 3, Male, Aged 40, Work injury).

Patients with a perceived mild degree of diplopia do not seem to experience the same functional limitations and consequently they do not have the same concerns as patients with no single vision. The following quote reflects the fact that single vision in the primary position "straight ahead vision" is what really concerns the patient. Having double vision away from the primary position does not seem to be a major concern.

"Obviously I was more worried about the straight ahead vision, rather than the peripheral.. If I can see straight ahead then obviously everything else that didn't really phase us as much" (Case 12, Male, Aged 21, Assault).

Another restrictive influence of diplopia occurs through affecting the individual's ability to drive. The sample reported that concerns over their ability to drive not only affected their work, but also their ability to participate in various everyday life activities. This aspect of the disabling influence of diplopia might make the patient feel unable to take full control of his/her environment (Mechanic, 1995). Ability to drive means the choice of mobility afforded by driving, thus it symbolises independence (Charmaz, 1983).

"Because I'm on my own going out to work is quite a bonus. So I was missing that a lot. And there are some friends who don't drive so they couldn't come to see me because I couldn't take them back after in the evenings." (Case 2, Female, Aged 62, Fall).

"I'm sick of sitting in the house. If I couldn't drive the car, I couldn't really see when I was walking, I was just … I was in the house for like over a week I didn't leave the house." (Case

20, Female, Aged 30, Assault).

Activity limitations caused by disabling illnesses impose their influence on patient's relationships with family, friends, employers, and other wider social circles (Falvo, 2005). This complex relation between health and social life has been attributed to the fact that disabling conditions challenge the individual's ability to perform their usual life activities and therefore also challenge the individual's self-perception (Falvo, 2005).

"I didn't want to go out because I was in absolute agony and I didn't want to go anywhere because I was … like psychologically it was pretty, pretty rough… there were some things that I didn't feel like doing." (Case 1, Female, Aged 24, Fall).

Bury (2002) stated that an individual's health plays an important role in shaping key factors of their social structure. The work environment, for some individuals, could also be an important part of their social relations. Trauma related disability, resulting in job loss, might therefore also lead to the loss of an important aspect of individual's social interaction (Horn, 2009). The following quote shows a patient's concern about her ability to fit in another job and new work team.

"I am anxious about sort of finding a new team and fitting in again. And the thought that I might be restricted as to where I can go and what I can do and how I can fit in because of my vision, is sort of an added anxiety" (Case 5, Female, Aged 48, Fall).

The disability related to diplopia might not be the only factor which causes social restrictions. Factors associated with the trauma itself seem to also play a role. The nature of a patient's response to trauma has been attributed to several factors one of which is the social context before and after the trauma (Carlson, 1997c). Our data suggests, however, that the social influence of a blow-out fracture appears to have bearing on the patient's self-esteem potentially leading them to feel stigmatised, and feeling vulnerable.

"Socialising, never even thought of it to tell you the truth, but that was a no, no. Work-wise it was very hard. You know? ……it's been hard in the sense that I couldn't go and see my customers. Rightly or wrongly in a sense that my pride was hurt." (Case 4, Male, Aged 48, Assault,).

In our sample it would appear that being assaulted has more of an influence on patients' social activities as opposed to having the fracture *per se*. Some assaulted patients in our sample tended to report needing more time to return to their social life. It might reflect two types of overprotective behaviours; physical and social. Patients who were not assaulted and sustained through their injuries through different mechanisms (fall and sport) tended to continue with their outdoor activities, but still tried to be cautious about their injured eye. On the other hand, patients who were assaulted tended to stay at home and avoid social places

"I became so obsessed with it that I just … I wouldn't let anything within about that far of my eye because I just was so scared that anything was going to come into contact with it because it was so painful. ...I was more cautious." (case 1, Female, aged 24, Fall).

"Saturday night I was suppose to go to a party but I refused. Which I just turned round and said no I'm not, because I'm not in a happy mood. I'm not myself. Just haven't been myself, so it's obviously, yeah, what's happened..... this is because of I can't see properly. Well and I'm down because of what's happening. Haven't been in the mood for it.... Well I'm just not myself, not my usual bubbly, up for a laugh, self. (Case 11, Male, Aged 26, Assault).

One of the factors that influences this over-protective behaviour seems to be related to self-esteem. Self-esteem can be defined as an appraisal concept adopted by individual to evaluate his competence and achievement. It is a part of personality concerned with motivation and self-regulation (Guindon, 2007). Despite the fact that self-esteem is an individual construct, it is, to certain extent, socially and culturally directed (Guindon, 2007; Gentile *et al.*, 2009).

Some male patients whom have been assaulted tend to use words like "being down" (Case 12) or "not myself" (Case 11) to describe their affected self-esteem. Some male patients reported that this trauma affects their "male pride" (Case 12). This might reflect frustration because they were unable to defend themselves against unexpected assault. Being unable to defend yourself seems to shake the masculine image for these patients. Frome and Eccles (1996) found that being masculine was positively related to self-esteem for males. They explained this by the fact that there is a social norm for males to be masculine and females to be feminine. This might show the selective effect of trauma on self-esteem. Self-esteem as a concept could be global, which is the overall evaluation of self-worth in general, and selective, which reflects the evaluation of specific quality within the self (Guindon, 2007).

"Probably say I feel a little bit down in myself. I'd probably say it's a little bit of like a male pride thing. Obviously if I was seeing … I don't know, it's hard to say, it's a hard feeling. ...... I don't know why I feel down. I really don't know." (Case 12, Male, Aged 21, Assault).

The social influence of this injury could also be viewed from the aspect of time. It appears that blow-out trauma has an immediate as well as a long term influence on patients' social activities. One of the immediate social trauma consequences might be related to the immediate physical trauma symptoms, like "black eye" (circumorbital ecchymosis). Patients reported a stigmatising effect of this appearance in the immediate post injury period. They reported staying at home to avoid being stigmatised.

The term stigma is used to refer to an attribute which is discrediting. A stigmatised person feels that he might not be accepted by others because of his disability or blemish because he does not know how others think about him (Goffman, 1963). Scambler (2009) added that stigma could be experienced or anticipated as a health related social devaluation. Stigma might be socially inflicted (enacted) or felt stigma. Enacted stigma refers to evident discrimination on the sole grounds of social unacceptability, while felt stigma reflects the sense of shame and fear of encountering enacted stigma (Scambler, 2009).

"..... When I had the black eye, I had a really bad black eye and my face was swollen and my cheek. And when I walked around and people would look at us it didn't make us feel very good. I was in the supermarket with my mum and I was getting quite a few dirty looks off people because they obviously thought I'd been fighting, sort of a thug, and that wasn't the case. So it wasn't nice to walk round and having the feeling that people might just be judging you on how you look. (Case 13, Male, Aged 19, Assault).

This reflects a type of felt stigma, it is a self-inflicted form of stigma (Nettleton, 2009). The following quote shows the embarrassing image the patient started to conceive because of the continuous clinching of the affected eye, to avoid double vision.

"[clinching the eye makes me feel] horrible, I feel people are looking at us all the time. Like when I'm sitting … when I'm out and I'm trying to like say if I'm reading a programme or if I'm watching a football match, I'm like that trying to look. I look like an idiot." (Case 20, Female, Aged 30, Assault).

Alteration of facial appearance as a result of this injury has its social consequences. These consequences may be connected with the patient's idea of his body image, and how it is perceived by other people. Altered body image has an additional negative influence on a patient's confidence. The face is a vital component of personality and body image (De Sousa, 2010), which is why facial scarring can significantly alter the patient's perception to his body image and negatively influences social function (Rankin and Borah, 2003; Levine *et al.*, 2005). The negative influence of the post-surgical facial scar was reported in our data.

"I mean it is a little bit scary because, you know, as I've said I like wearing make-up, you know, my appearance has always been important to me. It's an ego boost, it's a confidence thing. I'm not a very confident person and when I can feel as though I look nice it gives me that little bit extra confidence." (Case 5, Female, Aged 48, Fall).

"It still knocks me confidence. Because every time I look in the mirror that's all I see. I just see a big scar going across me cheek. .... it's just the whole thing really, it just annoys us the way it is. That obviously it's not how it was. It's got a scar and it's dropped down. Obviously nobody's going to be happy if somebody's got a scar on their face." (Case 17, Male, Aged 19, Assault).

The long term social influence of this type of injury might also be related to patient's feeling of vulnerability. The patient, after the injury, starts to behave in overprotective way. This also can seemingly negatively affect their usual outdoor and social activities

"I haven't been out since [the accident]. Well I went … I was out last night and I haven't been drinking at all. I've been scared to go to town now. I was a little bit worried in case … now I know how easy it can happen and that I haven't really got the confidence to go out properly with my friends and have a drink again." "[Because] I'm scared in case it happens again. I don't want to go out and … now, I've been out once since, and that was last night, and I didn't have a drink. So I wanted to make sure I was fully aware of everything that was going on and that I could see, make sure no-one was going to hit us again. (Case 13, Male, Aged 19, Assault).

Furthermore, if the injury was caused by an assault, as frequently reported by patients in this study, the patient might lose some of his confidence in people and social gathering places such as pubs and clubs. This can largely restrict the patient's social activities outside the close circle of family and close friends. This self-imposed limitation may reflect the patient's fear from being faced with the same problem again.

"The way the injury occurred obviously a blow to the face from someone unknown makes us a little bit wary of things. A little bit hesitant from things people … not knowing who people are and obviously stuff like that. A little bit more wary of my surroundings. ..... It might happen again because you don't know what society's like these days. So many different people out there that can turn and do things, you just don't know." (Case 13, Male, Aged 21, Assault).

"I know now that there is idiots out there and just by going out and trying to have a good night you can quite easily just get hit, be assaulted for no apparent reason. So I wasn't really confident about going out again and drinking. I didn't even want to put the chance out there that it could happen again really. I'd just rather stay safe." (Case 13, Male, Aged 19, Assault).

Moreover, some patients might feel that they are no longer living in safe living environment, because they were attacked by their flatmates or by people living in the neighbourhood. This might further restrict their social interaction due to their ability inability to deal with their (problematic) environment.

"My door used to always be open, always. If someone wants to come round they just walked

in the door. That's all stopped. Pull my curtains open now because I don't really want people to know if I'm in. I want to be in control of who comes into my flat. So I've gone very much more inwards." (Case 6, Male, Aged 45, Assault).

Another patient who was still taking antidepressant medication, for over a year since the injury, as he was still concerned about re-assault because the original alleged offenders were still living near him. This patient, however, had another blow out fracture in the same side which required another operation, but the second injury occurred in another city.

"I still haven't really dealt with them to be honest. I was on … after it happened the first time I was on the dole, well the sick for anxiety and depression because the lads that done it only live just round the corner. So there's every time I go out, and it's not as … every time I go out I see them and obviously like they want to fight again." (Case 17, Male, Aged 19, Assault).

The previous quotes showed different ways of social avoidance. Avoidance in its various forms such as social avoidance is generally considered as maladaptive coping strategies (Kildal *et al.*, 2005).

4.5.3 Coping

Coping procedures are cognitive and behavioural actions to improve health and to overcome or rehabilitate from diseases (Leventhal and Contrada, 1998). There are two major functions of coping: problem focused and emotional focused. Problem focused coping aims to change the troubled person-environment relationship by changing the environment itself. Emotion focused coping aims to either: a) change the stressful relationship with the environment through denial, or b) change and find another meaning for the problem. The latter form of emotion focus trauma is considered the most powerful and widely used coping mechanism to regulate stress (Lazarus, 1993).

Carver (2007) stated that problem focused coping aims to deal with the physical impact of the problem (stressor). In this perspective, physical coping could be considered as a type of problem focused coping. Problem focused coping is most likely when the stressor or the problem is viewed by the person as controllable (Carver, 2007). In this aspect dealing with the impairment caused by diplopia is a problem focused coping.

Both coping strategies have been identified within our data as being reportedly adopted by patients with blow out fractures; physical coping (problem focused) and psychological coping (emotional focused). Emotion focused coping is more likely to be adopted when the person views the stressor or the problem as an incontrollable event (Carver, 2007). In this aspect, the person's attempt to deal with the impact of the trauma is an emotional coping.

Physical (problem focused) coping

The study data show that there was a recurrent physical strategy reported by patients to deal with diplopia in the peripheral fields of gaze. This strategy involved adopting a compensatory head position which has been reported in the literature before in the case of vertical diplopia which results in a compensatory head flexion or extension Sullivan *et al* (1992)

Patients in our sample report that, over time, they start to adapt by moving their head towards the side where the diplopia occurs. Patients report that the use of a compensatory head position is most important during driving and using the stairs more than other life activities.

"I've already noticed that I'm starting to compensate for the areas of vision that I can't quite reach. Like I do just sort of automatically just tilt my head instead of looking up. I know my range." (Case 1, Female, Aged 24, Fall).

"I do drive, yeah. It was a little bit double vision when I did start to drive, and obviously when you were looking to the right and see things coming, I don't know, maybe off junctions or round roundabouts, it was hard to maybe judge cars the same way unless you actually turned your whole head instead of just using your eyes. But I think it's just something I've become adjusted to now. I wouldn't say the double vision's there as much, but obviously when it does come I do tend to move the head a little bit more than just using the eyes." (Case 12, Male, Aged 21, Assault).

If surgery is not a treatment option, sometimes prism glasses[5] are prescribed to help patients with certain degree of diplopia. Some patients, however, described wearing these prisms as unpleasant experience. It seems that some patients prefer, either a compensatory head position, or periods of "relaxation" for their eyes from time to time, as they report diplopia worsens with exhaustion.

"I didn't get on with them well.... so I lost them, but I was quite happy that I lost them. I literally probably maybe dealt with them for about six months. (Case 15, Male, Aged 24, Sport injury).

[5] A wedge shape refracting medium used to achieve binocularity Rowe F, editor (2000a). Glossary: Blackwell Science Ltd.

For cases where diplopia is in primary central filed of gaze the issue is different. It is not useful to manoeuvre the head position because diplopia is in the central field of vision. Some patients find it easier cover the effected eye, using their eye glasses, or just close the effected eye. Some female patients, however, do not like to "scrunch" their face to use the normal eye and as such they have to deal with the problem of double vision. Other patients reported becoming totally dependent on the family in doing their daily life activities.

"These are my glasses. I've just put tape on the back. What I think would have been good as well if I'd have been … you know, eye patches. If I had one of them from the start that would be easier because you do … on Thursday I was walking around feeling dizzy." (Case11,Male, aged 26, Assault).

"I didn't really manage that well, like I just had to deal with it, like I closed one eye." (case 17, Male, Aged 19, Assault).

Some patients used other ways to deal with constant diplopia (diplopia in the central field of vision). One patient noticed that the false (higher) image is weaker, so she started to rely on the (lower) stronger image. This adoptive mechanism has not been seen to be followed by other patients with diplopia in the primary gaze. This is possibly because it is not always consistently the same image which is incorrect: some patients see both images as real; despite they believe that one of them is unreliable.

"I think I just sort of got used to it really and knew that the one image was stronger than the other image I suppose. The lower image was stronger and was the correct one. So I could sort of ignore the upper image." (Case 2, Female, Aged 62, Fall).

"Well they're both real images, but this one was off-set to … if I was looking out that window it would be up there. So I would know that that's the wrong vision. If I went to touch it the window would be where this eye is seeing it, yeah. Now if I went to touch it with this eye – miles out, nowhere near." (Case 3, Male, Aged 40, Work injury).

Psychological (emotion focused) coping

Psychological coping has been defined as individual's attempts to preserve self-worth and value. It involves bringing meaning to the altered situation and its effects on body and soul (Bury, 2002). Individuals use coping to manage, control, or reduce the stress associated with significant life events in an attempt to restore psychological equilibrium after a traumatic event (Falvo, 2005). Coping can be: successful or unsuccessful; consolidated or fluid; consistent or inconsistent (Lazarus, 1993).

Psychological coping should be understood as the product of multiple biopsychosocial influences (Thomas, 2004a), as coping depends on other people's reaction towards the problem and the degree of emotional support and reinforcement provided by them (Bury, 2002). This may be the reason behind the difficulty in determining why people use specific coping strategies in relation to specific stressful encounter (Lazarus, 1993).

Psychological coping in trauma should also be considered with respect to active or passive coping strategies. In active psychological coping, the patients confront their condition, learning useful skills to help them to be engaged in treatment to control their condition.

"There's people much worse than yourself. You know, people have lost limbs, people have lost family members and life. People live in poverty. How do they cope in life? And that's, that's the way I think of things. I look at a negative situation – how can I make this positive?" (Case 3, Male, Aged 40, Work injury).

Alternatively in passive psychological coping, patients refuse to face the problem and try to deny its seriousness. Denial or avoidance aims to help them escape from feeling of distress. The essential problem with this way of coping is that it does nothing about the stressor or its impact (Carver, 2007). That is why it has been considered as maladaptive strategy (Falvo, 2005; Olff *et al.*, 2005).

It has been argued, however, that the dichotomy of acceptance and denial, as used by health care professionals, should be considered according to patient's perspective within the concept of optimism and pessimism. Some people with illness, as they hold the burden of the illness in the background (denial behaviour), can sustain the sense of well-being that allows them to live as they wish (Paterson, 2001).

It is believed that passive (denial or avoidance) coping is easier for patients with the presence of sort of distracting habits or behaviours that encourage the patient to avoid thinking about the trauma and its sequences (Olff *et al.*, 2005). Avoidance as a cognitive behaviour aims to protect the traumatised person's thoughts from exposure to reminders of the traumatic event (Carlson, 1997b).

"I just … I'm one of them who just get on with it. I'm not … sometimes I get angry and think 'why me' but then it just goes. I just watch the telly and take me mind off it. I just watch the telly and try not to think it's there until I've got to put my drops in and I realise and then it's there. You know, just sort of things like that, just try to forget about it. Put the telly on or have a bath or, you know, just put the radio on." (Case 14, Male, Aged 43, Assault).

"Now, in my life, what I do, you just get on with it. I don't do anything over dramatic or

anything" (Case 21, Male, Aged 47, Assault).

Blow-out fractures have the potential to be a life changing experience in both negative and positive ways. In fact there is evidence in the literature shows that trauma could have positive influence on people experience in different aspects, such as: perceived changes in self; a change sense with relationship with others; and a changed philosophy of life (Tedeschi and Calhoun, 1996).

"But actually with the eye condition as well, it has changed us on me outlook on certain aspects of my life, as I was saying before. It has made me like think about things differently. .... I think I've found me cloud to sit on. Do you know what I mean? Just like yeah, that's cool. I'm just like a bit more sort of humble with things. Do you know what I mean? .... I don't get extra stressed over stupid things anymore. Do you know what I mean? Like waiting in queues and sort of like, you know. .... I've just like cut a lot of things out. It has changed a lot, I know it's changed us like a person. I know that for a fact, because I actually feel different. I feel different towards things." (Case 6, Male, Aged 45, Assault).

On the other hand, the state of anger and frustration from the trauma could make the patient refuse to accept the physical limitations imposed as a result of the trauma, even if these limitations are minor degrees of diplopia. This might then present an obstacle in coping with the injury.

"My double vision is bad because it's there and it is an injury and it shouldn't be like that. You know, I have always had good vision and I shouldn't have to deal with it when I'm … even though, like I say, I shouldn't have to deal with it in my life." (Case 14, Male, Aged 43, Assault).

"Obviously it's not going to make you happy so it's just like … I'm not happy that I've had to have a scar there. At the end of the day I had no option, it was either that or I have no vision. But it's just like obviously I'm not really happy that I've got a scar above me eye. And I'm not exactly a good looking kid anyway and I need to try to keep all the looks that I can." (Case 17, Male, Aged 19, Assault).

Patients can perceive trauma as a sudden unexpected incident, in which they have become involved with often no justifiable cause. This, also, negatively influences the way patient can deal with the trauma. This can make it a difficult situation to deal with.

"I think it's always difficult to adjust to life when things happen very suddenly, whereas if things happen gradually, you have time to adjust yourself and find coping mechanisms in their own particular period of time. But if things happen very rapidly then sometimes it's difficult to cope with because, you know, you don't have time to find any mechanism to try to compensate for things." (Case 7, Male, Aged 32, Assault).

Some trauma patients may become incapacitated through trauma related depression due to its wide psychological influence. That is why it is important to understand the patient's need to help to overcome it (Horn, 2009).

"it was frustrating and boring and obviously I did feel a bit cabin, a bit cabin, feverish a little bit sort of claustrophobic not being able to go out and do much." (Case 1, Female, Aged 24, Fall).

The discussion of the data so far has shown that both the lack of knowledge about the blow-out fractures especially in the early post injury period and consequent fear about permanent visual loss can potentially exert a negative psychological influence. The patient becomes uncertain about their ability to cope with the prospect of possible loss of vision. This doubt is especially pertinent for patients who perceive (and/or possess) severe or complete double vision.

"It made me think, how I will cope with it. I don't know if I ever could cope with it. I really don't. I'm like … things like sort of like … I think it's like banging in to me heart and that. Seeing colours and seeing things are important to me like. I would rather go deaf; I would rather go deaf or mute than go blind." (Case 14, Male, Aged 43, Assault).

Trauma related psychological disturbances are known to impact on patient's cooperation during the treatment and recovery period (Hull *et al.*, 2003). However, the surgeon might help the patient to tackle the negative psychological effect of trauma. This could be achieved through active engagement of patients with their care (Coulter *et al.*, 2008). Our data demonstrated that having knowledge about the injury helps the patient to understand. Understanding the problem will enable the patient to adapt is a positive coping strategy, as it enables him to change his look toward his injury and overcome its effect (Coulter *et al.*, 2007).

Knowledge about the medical condition can provide the individual with an opportunity to conceptualise the disease process in a manner by which he is able to hold the disease in the background of his thoughts (Bury, 1991; Paterson, 2001). This foreground and background shifting perspective model (Paterson, 2001) suggests it is possible to shift the illness perspective from the foreground to background of one's mind. Paterson suggests that learning as much as possible about the disease will ensure a wellness in the foreground perspective. Accordingly, the self, not the affected (wounded) body, may then become the source of identity. The wellness in the foreground perspective separates the diseased body from the patient. The "wounded" or affected body will become objectivised and no longer control the patient.

Furthermore, knowledge, from the perspective of self-regulation, has an influence on coping through changing disease representation. Disease presentation and coping process are linked together. Within the context of self-regulation, people as health problem solvers attempt to improve their health and coping with disease as they define and re-define them (Leventhal and Contrada, 1998).

On the basis of our data, helping the patient to understand the difference between double vision and vision loss, from the beginning, might provide the patient with the early support they need. This early support could prove crucial as the immediate post injury period, which can last for a few weeks to months post trauma is when coping occurs (Tuval-Mashiach *et al.*, 2004).

"I felt confident as my vision is okay because the eye doctor gave me the impression that the vision itself, apart from there's a bit of damage to my pupil. There might be a little bit of glare. But it's the double vision. There's nothing wrong with my eye itself, it's the muscles around it and the movement needs lining up I think". (Case 11, Male, Aged 26, Assault).

The influence of such knowledge can be seen if the patient had previously experienced this type of trauma. The following quote shows how the patient perceives his blow-out injury when it occurred for the second time to the same side.

"I'd been hit in the exact same place and I felt like … it's funny but it was like a trapped nerve. Sort of like a trapped nerve like a funny like sting, weird to explain. But I knew that it had happened, I knew that it had been broke again... I was a lot more scared the first time because obviously I didn't know whether it would like go away or whether it was going to be really bad double vision all the time. But the second time like … I knew that I'd broke my eye again. The second time I was more worried about in case like you wouldn't fix it." (Case 17, Male, Aged 19, Assault).

The quote above also reflects the quality of communication this patient may have had during the previous treatment sessions. This communication then enabled the patient to understand his symptoms.

Some patients find that searching the web for the injury can help them to understand more about their problem and react more positively to the information provided by the surgeon. This, however, is not the case for all patients, since some seem to believe that these web sites provide general information, which is not necessarily related to the patient's specific condition.

"What I got from the internet was: Diagrams of the eye and the muscles and which muscles help move the eye and that, and this Just sort of gives an understanding of maybe what was wrong with my eye. So I kind of had an idea so when I'd seen the consultant and that just so I had a bit more of an idea when he was talking about stuff." (Case 14, Male, aged 43, Assault).

"[I did not look through the internet,] because it tells me nothing about me." (Case 7, Male, Aged 32, Assault).

Restoring the sense of life continuity (Influence of job and social support)

As previously discussed (section 5.2.2), it has been noticed earlier that fear of losing one's job is one of the elements which can add to the patient's suffering. In contrast, returning back to work positively influences patient's confidence. Loss of confidence, as shown earlier, is one of the indirect sequelae of the injury. It might be important, therefore for clinicians, to consider the patient's ability to work again as an important management outcome.

"[as I am going back to work] I'm starting to feel a bit more confident and I'm starting to feel happy that my eye's like and my cheeks, the swelling's gone away, the black eye's gone. I'm just waiting for the blood shot to go away and I'm feeling happy about it and a bit more confident and I'm starting to get back into being myself." (Case 8, Male, Aged 22, Assault).

"It concerned us a little bit but I was pleased more than anything because I'll be able to get on with … I won't have it as bad, I'll only have it when I look right up, so I should be able to drive okay and I should be able to do my job okay. In me daily life I should be alright. So it was a relief. (Case 14, Male, Aged 43, Assault).

The increase in confidence related to a patient's ability to perform his job is one of the reasons why patients report that they try to return to work even if they still be unable to perform their jobs in the way they used to. Although we cannot ignore the financial factor, still, regaining confidence through returning to work is an important part of patients' perceived recovery process.

The other positive aspect of returning to work is, as the patients report, the fact that it occupies their thoughts as opposed to the injury persistently occupying their thoughts. A frequent preoccupation with their injury reportedly makes it more difficult for the patient to be alone becuase his/her mind tends to be engaged with negative thoughts all the time.

"I've got to work. And basically that keeps your mind off things anyway. When you're fenced in the house that's when you start thinking about how bad it could be." (Case 4, Male, Aged

48, Assault).

Patients might cope with the trauma using more than one coping strategy. Family members and friends around the patient help provide the patient with the psychological support. Despite that Lazarus (1993) pointed out that social support seeking is not a consistent coping mechanism, our study data would suggest individuals with blow out fractures rely on both physical and psychological support provided by family members and friends.

"Luckily my partner's helped us out a little bit. Just generally like that really with obviously reassurance that obviously everything's going to be alright. The financial side of things. And same with family and friends made sure that obviously that if I need anything they're there." (Case 12, Male, Aged 21, Assault).

Glynn *et al* (2003) suggested that emotional support in the early post injury period plays a positive role on trauma patients. The lack of support in the early post trauma period, on the other hand, has been found associated with higher rate of post traumatic symptoms at 1 month from the injury.

Social support and communication might also be helpful factors in coping with distressing feelings associated with the disability (Bury, 1991; Mechanic, 1995). Charmaz (1983) explained that social contact can help minimise the patient feeling of "loss of self" as a result of his/her health problem. It gives the ill person the feeling of being valued as person and therefore "the loss of self" is incomplete. In this study's data this has been reflected by the fact that social support helped the patient regain confidence.

"[it was difficult 1st] Couple of days, yeah. And then like, you know, having family round and that was what, you know, pushed us and got the confidence and everything. (Case 16, Male, Aged 24, Assault).

In our study, social support took more than one form. Family members and friends might help the patient with his/her daily activities as well as providing him with potentially useful information concerning his/her condition.

"if my sister and I went to the shops, she's got this bag, like a shoulder bag, and she's really short. I'm 5'10", she's 5'1", and so if we walk … anywhere we walked I'd have my hand on the strap of her shoulder bag like she was my guide dog and … but we got so used to doing it, because we do a lot of stuff together like we hang out together a lot," (Case 1, Female, Aged 24, Fall).

"I kept talking to me mum and that about it. Told her … I like talking to me mum about stuff and that. A lot of my friends kept ringing, asked how I was, which was nice. I knew I had like

support and that. But I just really stayed in and just went down work when I had to and just tried to get on with it and tried to stay positive about it and just, you know, try to be optimistic about things." (Case 13, Male, aged 19, Assault).

In addition to the support patients received from family and close friends' circle, some patients also acknowledged the support they received in work environment. They reported the importance of this support in overcoming the difficulties they faced during period when they had a stressful work load.

"my bosses know that and I've got some help like and the other chefs are helping us, filling in and just making sure I'm doing alright. (Case 13, Male, Aged 19, Assault).

It is clear that the environment has an influence on coping with the injury and clinicians should try and ensure it is as supportive as possible in order to facilitate patients regaining confidence and minimising felt stigma.

"[In hospital] everything's very safe, very protected both emotionally and physically. So I haven't had to face a lot of the problems I might have faced in the outside world. .... Being a patient here is very protected, yes. It's very different to being out amongst the general population and having to mix with people and different people all the time. You know, standing in a check-out queue with lots of other strangers and a stranger on the check-out and, you know, getting a bus and people on the bus sort of, 'what's she done to her eye?' sort of thing." (Case 5, Female, Aged 48, Fall).

The positive influence of time

The positive effect of time, in terms of coping, can be seen in the post treatment period as it allows the patient to develop his coping methods with the injury complications. In this study data shows that there is no time limit for coping with blow-out fractures concurring with similar findings in the literature (2004).

It seems that the coping process starts as soon as the patient recovers from the "shock" of injury/assault, and realises that he/she does not have a choice but to accept and deal with the new situation. Coping processes are than established as the patient develops his own mechanisms to deal with the outcome of trauma.

"I coped as best as I could to be honest, it wasn't like … I just had to deal with it. When it first happened I didn't deal with it too great because obviously like me face was … I looked like a completely different kid, me face was out here and it was just … like I was shocked when I first saw like the injury and that. But like I say you've just got to deal with it any way you can really." (Case 17, Male, Aged 19, Assault).

"Obviously you can get used to it, you adjust to anything. If you go into a wheelchair you can get used to it. You can get used to anything if....... I've generated techniques to make it better. So there's no one point where I thought right I've got to say "I've got to do this now to make it better." (Case 15, Male, Aged 24, Sport injury).

"It doesn't that really bother [me if I move my head while I am driving]. If you think about it, it probably did [at the beginning], but I'm so used to it now. I don't know how to say it. I mean like I said funny enough something minor it might go away. But obviously as it gradually" (Case 1, Female, Aged 24, Fall).

The interviews with blow-out fracture patients have shown that there are different ways of coping with this injury and its complications. Although, most of the coping methods are patient related mechanisms, it should be noted that successful surgery in term of regaining acceptable level of single vision (regaining confidence) and elimination of enophthalmos (satisfaction with appearance) have a major influence on patient ability to cope with the injury and its complication. Auerbach *et al* (2008) also found that the extent of emotion-focused coping strategies was related to patients' satisfaction with facial appearance.

Bury (1982) suggested that illness itself represents a type of disruptive event. Accordingly, patients with illnesses conceptualise their lives as two halves, before and after the onset of the illness. Coping process, on the other hand, try to bridge that break in life continuity. It would seem on the basis of our data that orbital blow-out fractures might have similar disruptive effect as illness, especially as some of the results of the fracture such as diplopia and or enophthalmos are long-lasting (chronic) and therefore have to be managed similarly to a chronic illness, as the following quote shows;

"I shouldn't beat myself up about it. I look at the positive things that I'm still here. .... just trying to get myself better rather than get myself hooked up in thinking about it all the time."(Case 16, Male, Aged 24, Assault).

The quote above reflects an attempt at "Normalisation", in which the patient is trying to avoid the psychological "bracketing" of the impact of the illness (Bury, 1991) and trying to continue with life as far as possible as before. The process of normalization might be accumulative process. It develops "broaden-and build", and this achieved when coping skills improve with time (Friedman, 2007).

"Although, physically it's [diplopia] likely not to improve, I think that my brain must be doing all sorts of amazing things that I'm unaware of to cope with it, to compensate for it and find ways around it. Because I'm finding that I'm aware of it less and less and I think that over time, after about a month I… didn't had to have had my eye covered or I couldn't see.

Which sounds weird but, yeah." (Case 1, Female, Aged 24, Fall).

4.5.4 Summary

This study attempted to explain aspects of patients' experience which could be of clinical relevance to assist clinicians to provide more comprehensive approach in blow-out fracture management. Data analysis has revealed multi-factorial influences on patient's perceived outcome including positive and negative influence patient experience.

Patients with blow-out fractures mainly experience distress and frustration in variable degrees. These negative feelings occur as a result of trauma itself and the concomitant fear and uncertainty. Fear is a usual response to trauma. In blow out fractures of the orbit, however, it is mainly centred around the fear of losing vision, inability to work and inability to drive, in addition to the uncertainty about the result of treatment. This fear and uncertainty is related to: the presence of diplopia which is perceived by the patient as a visual acuity problem; inability to understand the reason behind this diplopia (lack of biomedical knowledge) and ineffective communication. The extended time before definitive diagnosis and explanation or treatment, within this context, is a joint factor which provokes the negative influence of other factors.

On the other hand, time after treatment seems to positively influence the patient's ability to cope with the injury. With increased time post definitive treatment, patients seem to better understand their injury and equipped with confidence through ability to return to work and through social support. These factors help patients to regain their confidence about their ability to continue with their life. The summary of the study findings is shown in Figure 4-3 and Figure 4-4.

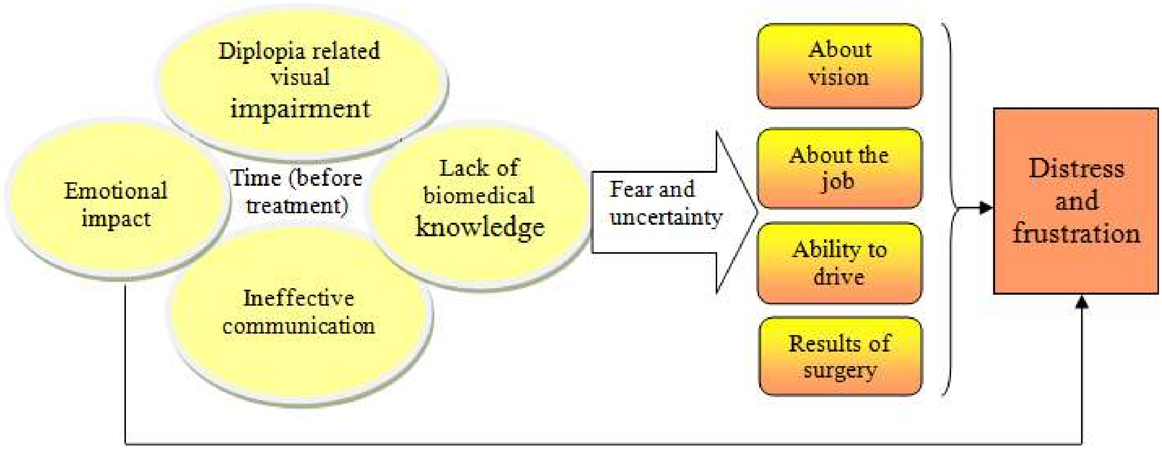

Figure 4-3 Factors negatively influencing the outcome

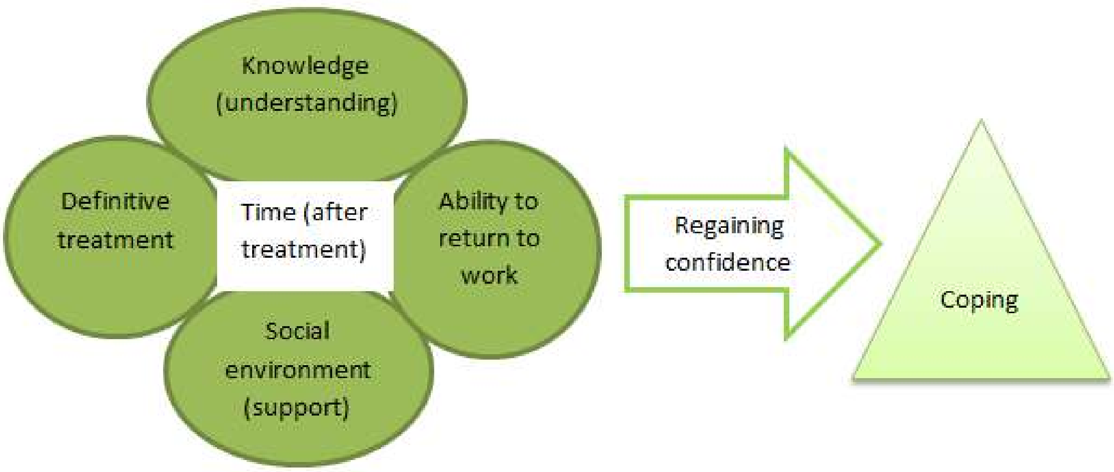

Figure 4-4 Factors positively influencing the outcome

Chapter 5 Closing Discussion

Management of blow-out fractures of the orbit is a controversial issue. Since 1974 the management of blow-out fracture has been controversial (Dortzbach, 1985). This controversy does not involve just the choice of management, but it diffuses through management details, starting from orthoptic measurement tools, timing of surgery, surgical approach, the choice of implant material and the follow up protocol.

The controversy seems to be related mainly to the ocular motility outcome, which has been described as less than ideal compared to enophthalmos (Harris, 2006). This could be attributed to the subjectivity of diplopia assessment (Dutton, 1991; Mustaffa *et al.*, 2008), multi- disciplinary involvement (Yano *et al.*, 2009) and the fact that most of the previous prospective studies have suffered from relatively small patient numbers. Such studies have suffered from a shortage of patients for several reasons, including uncommon injury presentation, insufficient period of study and issues with 'reliability' of the maxillofacial trauma population. More recently, there have been studies published with higher patient numbers (Jin *et al.*, 2007; Han and Chi, 2011; Higashino *et al.*, 2011; Shin *et al.*, 2011), which has provided the literature with more robust conclusions in regard to the factors which might influence management in relation to diplopia. However, lack of unifying measurement of diplopia still represents an obstacle toward the effort to provide a unifying aspect in term of blow-out fractures' management.

As a busy trauma unit, the Oral and Maxillofacial Department in Newcastle General Hospital manages a relatively large number of blow-out fractures, operatively treating about thirty cases per year.

5.1 Original Plan of Study

This study was originally envisaged to have three major arms: a retrospective, a prospective and a qualitative study. The retrospective study has taken the form of an audit of a large, comprehensive, although incomplete data set, gathered over a ten-year period. The reason for the retrospective audit was to ensure that there was sufficient data to enable some robust conclusions concerning the factors that might influence ocular motility outcome. The qualitative study arm aimed to include the patients' perspective as a management aid, through understanding patient's experience during the management journey and identify coping strategies to overcome orbital blow-out fracture problems.

The objectives of the prospective longitudinal exploratory study (third study) were to:

I) Obtain data on the longitudinal changes in orthoptic indices (BSV, UFOF) following treatment for blow-out fractures by serial orthoptic examinations.

II) Obtain data on the patients' perceived changes in double vision (diplopia) over time by the use of self-report diplopia diaries, including diplopia score (Adams *et al.*, 2008), self-reported diplopia (VAS) and global transition scales.

III) Use the diplopia diary and serial orthoptic indices data to help define improvers from non-improvers in the sample

IV) Use the improver's diplopia diary data and serial orthoptic indices data to help determine a review[6] point and reference period[7] for patients with orbital blow-out fractures.

V) Obtain pilot data from the whole sample and controls on the validity and responsiveness of two quality of life measures (SF-36 and Amblyopia and Strabismus questionnaire) giving an indication which of these measures was most appropriate for further testing in future research.

There were, however, some practical problems, in that the majority of patients refused to agree to participate in this study, the most common reason given being difficulty in to committing to such a follow up schedule (4-6 additional follow up visits). This reluctance to attend had not been anticipated. However, even with reducing the number of follow-up visits to 2 visits (one month and 3 months respectively) and such data had been collected, there were issues:

[6] Review point – the point in time when clinical improvement has reached a plateau and clinicians will be able to determine the surgery's effect

[7] Reference period – working back from the review point the time over which patients are most likely to have noticed significant change in their condition

- It is difficult to compare between the clinical data and quality of life measures since the time differences between the clinical appointments (where the quality of life questionnaires to be answered) and orthoptic appointments might be more than one week.

- It is difficult to fit the patient orthoptic appointment into 1 month and 3months postoperatively, because of the time availability. It was, also, difficult to fit orthoptic appointment with the surgical appointments. As a result it would be difficult to compare the orthoptic and quality of life measures data between the cases.

For the above reasons, it was difficult to continue with the longitudinal prospective study

5.2 Retrospective study (study A)

The main focus of the retrospective study was to investigate the possible factors that might influence ocular motility and diplopia outcome following orbital trauma. In relation to enophthalmos, it has been felt that there has been, over the last decade, general agreement about the relationship of orbital size changes and resultant enophthalmos. In contrast, diplopia, which is considered by some to be the most important complication of orbital blow-out fracture (Orgel, 1971) appears to be the main issue in management dilemma.

It is difficult to identify a single major cause of diplopia in orbital wall fractures (Lee *et al.*, 2005), which is why it has been considered as a multi factorial condition by some authors (Holmes *et al.*, 2000). There have been three suggested causes, as discussed in the literature, for diplopia: direct musculo-fascial complex injury; orbital tissue involvement in the fracture defect; and nerve injury.

Iliff *et al* (1999) and Manson (2007) suggest that muscle contusion and fibrosis of the musculo-fascial network play an important role in diplopia associated with blow-out fractures. Iliff *et a*l (1999) found that both angiogram and histological studies did not confirm compartment syndrome, suggested by Smith et al in (1984), as being a cause of extraocular muscle motility disturbances. Furthermore, they did not support the concept of nerve injury as a frequent cause of extraocular motility disturbances as oculomotor (III) nerve branches which enter the orbit though the superior orbital fissure travel inside the muscle cone and they are well protected. They did report, however, the close proximity of inferior oblique branch of III nerve to the orbital floor, which makes it vulnerable. This has been supported by

Kakizaki et al (2005) who documented the incarceration of the inferior oblique branch of the oculomotor nerve in two cases of orbital floor trapdoor fractures.

In contrast, Yano *et al* (2009) argued that extraocular muscles are less susceptible to injury, as they float in well vascularised adipose tissue, and if they are damaged, they recover faster than injured muscles in other parts of the body. However, evidence from the literature (Ludwig and Brown, 2002; Yip *et al.*, 2006; Huerva *et al.*, 2008) suggests that muscle injury might be considerable, since strabismus surgery has been reported to be required in postsurgical cases of blow-out fractures in this study and others (Gosse *et al.*, 2009).

Orbital tissue involvement, other than the extra ocular muscles themselves, has also been suggested to be the major cause of diplopia (Converse and Smith, 1957; Gilbard *et al.*, 1985; Harris *et al.*, 1998). Totsuka and Koide (1997) , using animated MRI study, found incarcerated connective tissue septa to be the main cause of motility problems in blow-out fractures. They suggested that incarcerated septa at the fracture site causes restricted eye movement through their interference with the contraction and relaxation of the external ocular muscles.

According to the assumption of hydraulic theory, the pressure exerted by backward displacement of the eyeball has its impact on the muscular fascial network. The close proximity of inferior rectus muscle to the orbital floor in posterior orbit makes it more susceptible to contusion after fracture. Whereas, in the anterior half of the orbit the extraocular muscles are protected by a cushion of extramuscular fat (Iliff *et al.*, 1999). The pressure effect by the eyeball, in addition to the frictional or mechanical effect of orbital tissue involvement in the fracture, may certainly have a contusive effect. This assumption is supported by reported cases of extraocular muscle flap tear and avulsion at their eyeball insertion site as a consequence of blow out fracture (Ludwig and Brown, 2002; Yip *et al.*, 2006; Huerva *et al.*, 2008)

However, the significant percentage of conservatively managed cases in our study and other studies might suggest otherwise. It seems that the anatomy of the orbital floor itself acts as a shock absorber, not only to protect the eyeball from significant damage in this type of injury, as suggested by Kellman and Schmidt (2009), but it may also have some protective effect over the fibro-fatty muscular network (musculo-fascial complex). In addition, some of this damage could be overcome by high healing potential of extraocular muscles (Yano *et al.*, 2009). This might explain why loss of binocularity is not disabling in most of blow-out fracture cases (Jones, 1994). What might support this assumption from this study is the fact that fracture size was not significantly related to the severity of both BSV and UFOF scores.

It seems that direct muscle injury as a result of this type of trauma has not received enough attention in terms of surgical decision-making. The primary aim of surgical repair for blow-out fracture is to minimise orbital soft tissue damage and to restore a full field of functional binocular single vision (Carroll and Ng, 2010). This is usually achieved through releasing of the herniated or entrapped orbital tissue in the fracture defect. However, tissue involvement in orbital blow out fracture, for which surgery aim to rectify, is not the only influential factor on ocular motility. Damage to the fibro-fatty-muscular complex should be considered in this type of injury (Koornneef, 1982; Iliff *et al.*, 1999; Manson, 2007). Therefore, the outcome of surgery might be unpredictable, as the extent of orbital tissue damage and it contribution to ocular motility deficit may not be readily determined at the time of injury or by the extent of its involvement in the fracture.

The controversy regarding surgical intervention versus conservative management may not reflect only the inability to predict, on clinical basis, who would recover from the ocular motility disturbances (Gosse *et al.*, 2009), but may be related, as our data has shown, to the limited role of surgery in terms of timing, approach and the type of implant material in improving the ocular motility outcome.

Evidently surgery does not provide the ideal solution for all ocular motility problems in this type of trauma. About 80% of our cases presented with variable degrees of diplopia postoperatively. Furthermore, cases with low preoperative diplopia scores which showed better improvement in comparison with higher BSV scores, which might justify surgical intervention, were still at risk of an unfavourable outcome, i.e. incomplete, symptomatic, resolution. Moreover, cases with orbital muscle herniation, which represent a positive criterion for surgery, were also under the risk of unfavourable outcome.

Koornneef (1982) believed that surgical management of a pure blow-out fracture may not address the real cause of the diplopia, which is disruption of the ligament system and septa. This could be the reason behind the fact that diplopia is unlikely to be completely corrected by surgery (Jones, 1994; Kugelberg *et al.*, 1998; Stassen and Kerawala, 2007), which concurs with our findings.

Although making a decision as for the need for surgery in blow out fracture is difficult (Mathog, 2000), it is logical to assume that an effective approach for management of diplopia in this type of injury should consider more than one factor. Our study suggests that these factors should include a preoperative BSV score consideration of the level of tissue herniation.

Our data showed that preoperative BSV score has an important prognostic value in term of postoperative diplopia score, follow up time, number of post-operative visits and subjective diplopia outcome. It also showed that patients with BSV >80% score do not benefit from surgery, while patients with BSV <60% benefit from surgery more than other BSV categories in terms of BSV improvement.

However, BSV score could not be used alone as surgical management guide criterion. It shows the severity of diplopia, but does not give the exact cause behind it. Surgery aims to restore single vision through restoring the normal position of the herniated or entrapped orbital tissue, as such, it worth considering the influence of tissue involvement on binocular vision. It appears from our data, that orbital fat herniation, which forms about half of the cases with surgical intervention, has no significant influence when compared to no tissue herniation in relation to diplopia and ocular motility. It is logical to suggest decreasing the number of surgical interventions according to this finding. However, this could be further addressed in the future studies.

Because of lack of adequate follow up data, from the conservative patients' group it would be difficult to suggest definitive guide for the management of blow-out fractures of the orbit. It is possible, however, to provide a figure about the potential benefit of surgery for different levels of preoperative BSV score: Surgical intervention would be more beneficial in terms of postoperative BSV scores for cases with orbital muscle entrapment / muscle herniation with preoperative BSV score ≤60%. Conservative management might be considered for cases with BSV ≥80% even with orbital muscle herniation. In the 60-80% BSV range, the level of tissue herniation may advise the need for surgical intervention.

5.3 Qualitative Interview Study (study B)

Providing measurements and figures might help guide management decisions. However, numbers and measurement are not necessarily representative of the effects of blow-out fractures on patient daily lives: they do not explain or help clinicians understand the biopsychosocial impact of the fracture on patients. Accordingly, clinical definitions or classifications might not provide us with all the information we need for comprehensive health management planning (WHO, 2002).

The goal of medical care for most patients today is to improve QOL through maintaining functioning and well-being. Consequently, there is an increasing consensus that the patient's perspective is pivotal in monitoring outcomes of medical care (Kahaly et al 2002). This is particularly important when management decisions are not clear-cut through lack of evidence or other reasons. In such cases it is imperative to study the health problems from all possible aspects. To achieve this aim we studied the patients' experiences of blow-out fractures of the orbit, in a hope to optimise current management by improving the clinician's understanding of orbital trauma patients' perceived experiences and outcome.

The qualitative study showed an understandable deficiency of knowledge about blow-out fractures form patients, who perceived the injury as potential visual loss. This subsequently leads to the fear of being unable to return to their normal lives and, also led to uncertainty over the outcome of treatment. Sometimes, the health care provider, unintentionally, appeared to compound this deficiency of knowledge and consequent uncertainty through their biomedical perspective and ineffective communication of the bony nature of the injury.

Man, as an inquisitive creature, lives in world of questions. Through the course of uninterrupted life events the man maintains the logic of continuity. Answers for undisturbed life events, by the virtue of continuity, are obtainable. In cases of trauma or disrupted life events answers may need to be searched for and may be difficult to find and therefore this disrupts the continuity of life (Tuval-Mashiach *et al.*, 2004).

This importance of a patient's knowledge about his/her condition might be related to the fact that knowledge could be the core of coping process. The importance of knowledge in coping with trauma could be seen in the immediate response toward trauma, when the injured patient asks "why?" Patients with this type of trauma might address or answer this question differently: some accept the fact of trauma; some seem to believe that it is a punishment; others, just refuse to deal with it as a fact. Whatever the answer is, the patient has to put the answer in the context of his life. When the patient finds his/her answer, with time, the coping process starts to build up and the patient regains life continuity and becomes re-engaged with the logic of continuity (Crossley, 2000).

Some of the patients responded to the trauma by saying “It should have not happened”[8]. This may reflect a denial of a situation that could happen to anyone. What might help the patient to reverse this denial is knowledge about the true nature of this injury. When we know about something, this means that this thing exists, otherwise we would have not known about it. Knowledge can help the patient to understand that trauma, disability and disease can be inevitable parts of our lives and that there are ways to manage them. Through this acceptance, the patient might be able to contain their problem and continue with their lives.

In addition, when an individual is supported by family members or friends who live in normal life’s logic, this, also, might help them to overcome the disruptive effect of an injury. Social support might surround the patient with the logic of continuity encouraging them to continue to adapt to their new life circumstances. Social support in this sense has been mentioned by Friedman (2007) as he referred to group of patients with “self-healing personality”. These individuals tend to evoke positive reaction from others, promoting good physical health and subsequently good mental health. In contrast absence of support might isolate the patient and put him under the control of disrupted life logic.

5.4 Final Summary

It seems that there is a relation between clinical (orthoptic) diplopia score and diplopia as perceived by the patient. This relation mainly centres on whether diplopia is complete (0%) or there is certain degree of single vision. Patients with complete double vision appear to be more apprehensive about the possibility of visual loss and do not really seem to differentiate between complete diplopia and vision loss. Patients with a degree of single vision, on the other hand, can appreciate the difference between visual loss and double vision because they are able to see, mainly in the primary central field of gaze.

Data from the retrospective and qualitative studies show some relation between BSV score level and patient willingness to perform surgery. It seems that the less BSV level and the less ability for patient to see the more willingness for patient to undergo surgery, while patients with high BSV scores appear to be more reluctant to undergo surgery.

[8] Case no. 3 and case no. 10

Patients with complete double vision (0% BSV score) tend to report that decision to undergo surgery is an easy one to make. This seems related to the hope that surgery will restore their vision and this in turn will influence their ability to do their jobs and continue their daily lives unimpeded.

The retrospective study data showed that surgical timing, within one month window has no significant influence on both postoperative diplopia score and subjective diplopia outcome. However, time in terms of the patient experiences identified different issue. In the qualitative data, extended period of time preoperatively seems to have negative influence on the patient's reaction to their injury, especially if the patient does not know if he is going to lose his/her vision or will become diplopic for the rest of his life.

Surgeons should, therefore, consider the influence of waiting on patient's concerns, especially if the patient thinks that s/he has potential visual loss. Surgeons when considering bioclinical factors in surgical timing, should also consider patient's worries and address these fears in a way makes waiting for surgery less stressful.

The retrospective study has shown that preoperative BSV score has a significant association with subjective outcome compared to UFOF. However, there was no significant relationship between BSV scores improvement and subjective outcome in relation to diplopia. This might reflect that the degree of BSV score improvement does not exactly meet patients' expectations in relation to the improvement of their double vision and therefore there might be more factors to take into account in assessing outcome than just objective improvement in double vision.

Measurements and numbers frequently guide our clinical judgements and treatment planning. However, it is important for clinicians to embrace a more interpretivist and holistic approach in their attempt to understand the health problem they are dealing with. Otherwise they might miss important opportunities to improve their ability to help the patient through their journey through different health problems and challenges.

Patients' reported experience of blow-out fractures of the orbit demonstrates that proper patient-physician communication is pivotal to management. Clinical measures adopted in the treatment of this type of injury, whether conservative or surgical, might not be able to address direct muscle injury, the fact that might leave the patient with certain level of double vision.

It might be possible, however, to help the patient to cope with this possible outcome through providing suitable answers that address patient’s deficient knowledge and concerns. The qualitative data showed that patient management is not a single sided aspect. Successful outcome of any health care is a collaborative effort that targets the patient as well as the disease process.

Chapter 6 Conclusions and Suggestions

6.1 Conclusions

6.1.1 Retrospective study

The first objective was to study the influence of demographic, radiographic and surgical factors on diplopia in blow-out fractures of the orbit. Patient demographics have been found to have no significant influence on preoperative or postoperative diplopia scores. They also had no influence on subjective diplopia outcome in the surgical group.

Similarly, the radiographically determined size of the fracture was found to have no significant influence on the level of tissue herniation. It also had no significant influence on preoperative diplopia, postoperative diplopia, or subjective outcome in relation to diplopia.

In this study, timing of surgery, surgical approach and the choice of implant material had no significant influence on postoperative diplopia score, diplopia score improvement and the subjective outcome in relation to diplopia.

Orbital fat herniation, in the absence of muscle herniation, appears to have no significant influence on diplopia, showing similar outcomes when compared to fractures with no tissue herniation on diplopia scores in blow-out fractures. However, when orbital muscle herniation is observed, this has significant negative influence compared to no tissue herniation on diplopia scores. Patients with orbital muscle herniation are more likely to be at risk of unfavourable outcome in relation to diplopia.

The second objective was to assess prognostic role of BSV in blow-out fracture management. BSV has a significant prognostic value in blow-out fractures of the orbit. The lower the preoperative diplopia and ocular motility scores the more chance of improvement in both diplopia and ocular motility scores after surgery. In addition, it was noted that the lower the preoperative diplopia score, the greater the number of follow-up visits and longer the length follow-up time.

6.1.2 Qualitative study

The first objective of this study was to investigate the psychosocial impacts of orbital blow out fractures on the patients. The psychological impact of blow-out fractures on the patients was reflected through distress and frustration which negatively influence patient’s daily activities including their employment. The distress and frustration were reported to centre on the individual's fear of losing their vision, and consequently being unable to work and drive. This fear was compounded by their uncertainty about the result of treatment. Individuals' fear and uncertainty appears to be related to the generalized perception, expressed throughout the sample, that diplopia is a visual acuity problem as opposed to a mechanical entrapment causing secondary visual disturbance. This misconception potentially appears to be due to ineffective clinician communication leading to a lack of patient knowledge.

The social impact of blow-out fractures seems to be related to the limitations caused by diplopia on daily activities which challenge the individual's perception of self. Blow-out fractures also appear to have a bearing on the patient's self-esteem, potentially leading them to feel stigmatized and vulnerable.

The second objective of this study was to explore patients' adaptation to orbital blow-out fractures. The lack of information leading to a misunderstanding to the nature of the injury as globe injury rather than bony injury may affect their ability to adapt. The adaptive mechanisms reported tended to vary between patients with the most common adaptive technique being to adopt a slightly altered head position in order to compensate for the diplopia.

A better understanding of the nature of the injury might help the patients to regain their confidence in relation to conducting their daily activities and therefore resume their normal lives. Within the qualitative data social support emerged as an important influence on positive adaptation to the injury.

6.2 Suggestions for clinical practice

It is recommended that BSV scores should be considered as a unifying measurement tool for diplopia assessment in orbital blow-out fracture cases, because of its prognostic value in relation to diplopia outcome.

It is suggested that surgery should be recommended for cases with BSV scores ≤60 with orbital muscle herniation/entrapment, whereas an initial conservative approach may be taken for patients with diplopia score ≥80, with no tissue herniation or with orbital fat herniation only.

The results of the qualitative study suggest that we should endeavor to improve patients' knowledge at the time of presentation. This would improve patient's understanding about the injury and help him/her to cope with the possible outcomes, some of which might not be anticipated by the patient. Improvement of pain control in some cases might help reduce anxiety during the period of the injury.

6.3 Suggestions for further research

6.3.1 Determining review point and reference period

It could be suggested that 'diplopia diaries' and serial orthoptic examinations be compared to the self-report global transition scores completed at each orthoptic examination. This would help to determine the responsiveness to perceived change and might be helpful to identify review points and follow-up period. This was initially attempted in this study, however, it was difficult to achieve. To overcome this difficulty, the number of orthoptic follow-up visits need to be reduced. More time would also be required to allow the patient to answer the Quality Of Life Questionnaires during each orthoptic visit.

6.3.2 Identifying putative items for orbital trauma questionnaire

Data from semi-structured interviews can be used to help identify items for a suggested orbital trauma questionnaire. These data will be incorporated with the Amblyopia and Strabismus Questionnaire, which will be used as a scaffolding instrument (Guyatt *et al.*, 1986). Employment of such an instrument is likely to help clinicians assess orbital trauma patients' outcomes better. This has already started and a study with suggested orbital trauma outcome measure is in its writing stage. It is hoped to be published in the near future (appendix p.37).

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Appendix

1. Ethics committee approval

The Newcastle upon Tyne Hospitals NHS
NHS Trust

The Freeman Hospital
High Heaton
Newcastle upon Tyne
NE7 7DN

Tel: 0191 233 6161
Fax: 0191 213 1968

LRF/JW

24th February 2010

Professor M Greenwood
Consultant Oral and Maxillofacial Surgeon
Oral and Maxillofacial Surgery
School of Dental Sciences
Framlington Place
NE2 4BW

Dear Professor Greenwood

Trust R&D Project:	**5099**
Title of Project:	**Blow out fractures of the orbit; determining patient-based clinical outcome**
Principal Investigator	**Professor Mark Greenwood**
Number of patients:	**60**
Funder (proposed):	**University of Newcastle Upon Tyne**
Sponsor (proposed):	**Newcastle Upon Tyne Hospitals NHS Foundation Trust**
REC number:	**09/H0907/73**

Having carried out the necessary risk and site assessment for the above research project, Newcastle upon Tyne Hospitals NHS Foundation Trust grants NHS R&D approval for this research to take place at this Trust dependent upon:

(i) you, as Principal Investigator, agreeing to comply with the Department of Health's Research Governance Framework for Health and Social Care, and understanding their responsibilities and duties (a copy of responsibilities prepared by the Trust R&D Office is enclosed)

(ii) you, as Principal Investigator, ensuring compliance of the project with all other legislation and guidelines including Caldicott Guardian approvals and compliance with the Data Protection Act 1998, Health and Safety at Work Act 1974, any requirements of the MHRA (*eg* CTA, EudraCT registration), and any other relevant UK/European guidelines or legislation (*eg* reporting of suspected adverse incidents).

Sponsorship

The Newcastle upon Tyne Hospitals NHS Foundation Trust will act as Sponsor for this project, under the Department of Health's guidelines for research in health and social care.

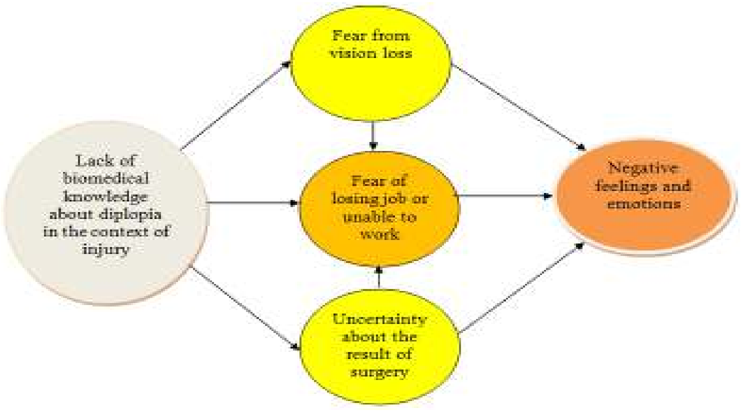
In addition, the Trust has a Research Governance Implementation Plan, agreed with the Department of Health, in order to fully comply with Research Governance and fulfil the responsibility of a Sponsor.

2. Qualitative topic guide

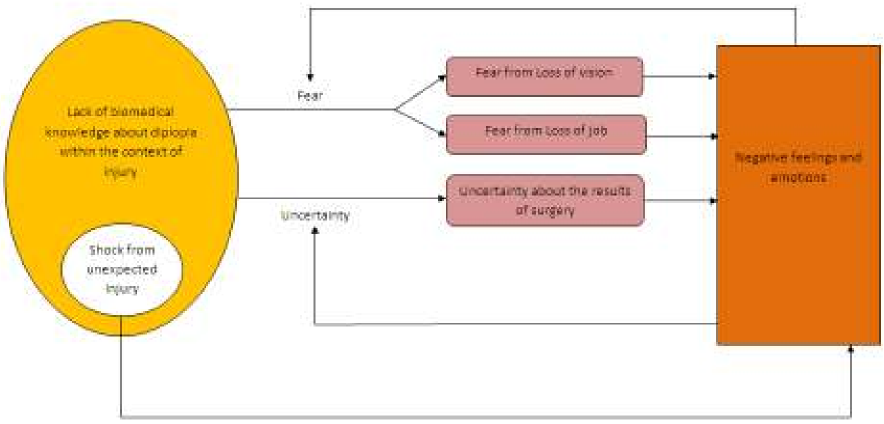
- Initial concept of injury (ex: what did you did you think about injury; how did you find the severity of it?)
    - Degree of severity
    - Seriousness
    - Likely effects
- Daily effects of: (what did you feel immediately after the injury, what were your concerns about it?)
    - Episode of trauma – pain, worry etc
    - Injury
    - Double vision
    - Surgery or conservative management
- Psychological consequences of trauma, injury and double vision: (what did you think about your double vision?)
    - Worries or concerns over surgery, injury, vision
    - Self-confidence and appearance
- Social effects of injury/surgery
    - Socialising
    - Work and personal relationships
- Self-management of on-going problems
    - Double vision
    - Surgical complications
- Any degree of handicap pre or post therapy for injury
    - Financial loss
    - Satisfaction with life
    - Level of functioning

Coping with the injury (added as the data collection and analysis progressed)

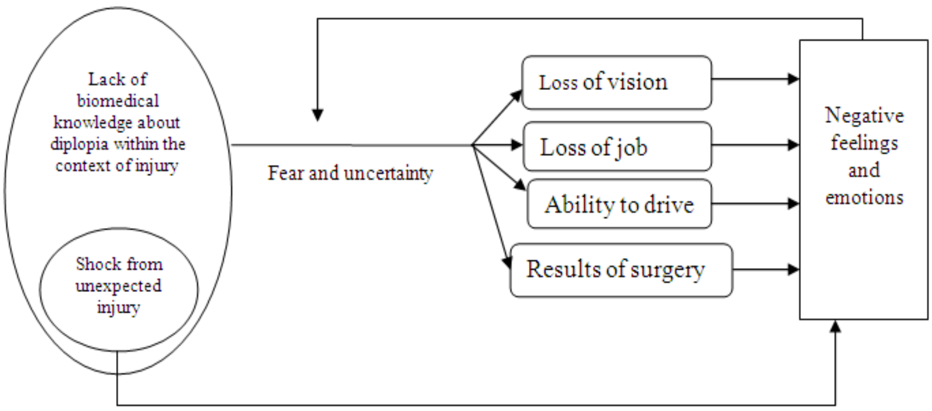
3. Theoretical construct for the post injury period



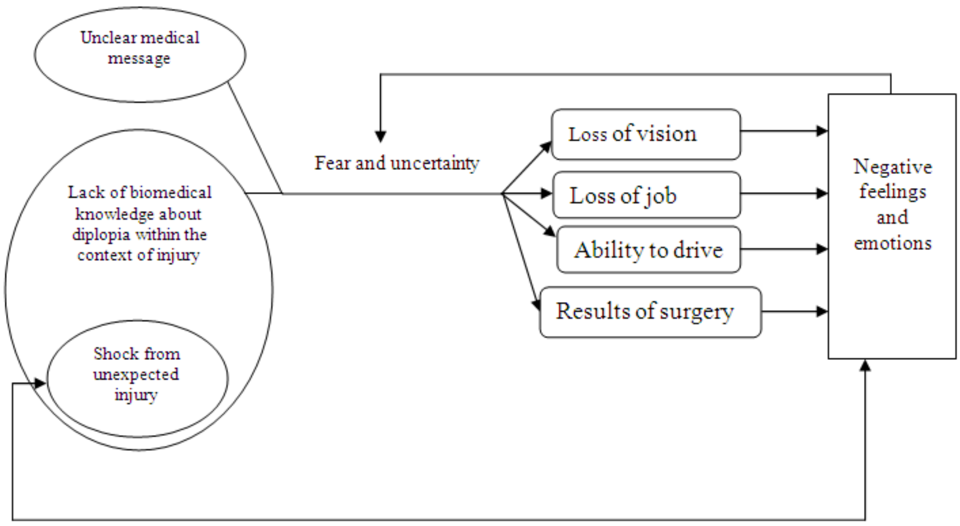
Model 1 ver.1



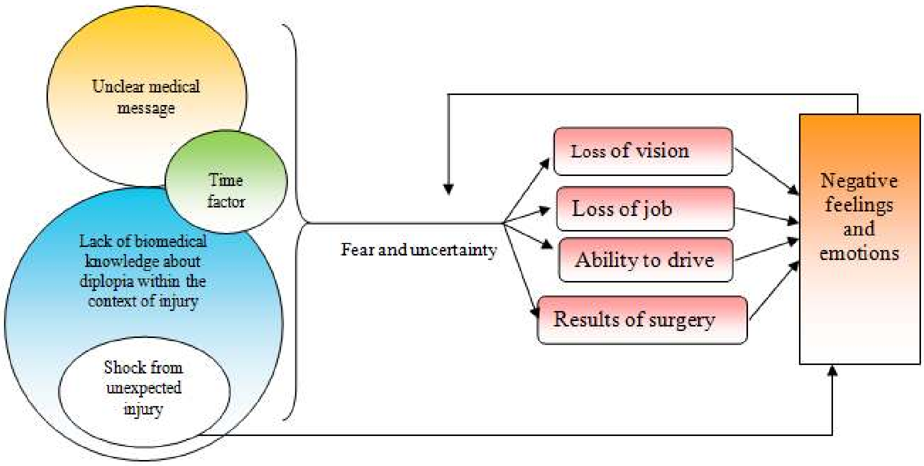
Model 1 ver.2



Model 1 ver.3

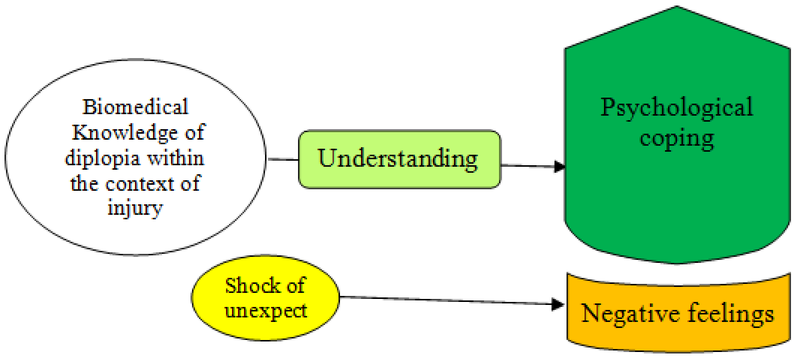


Model 1 ver. 4

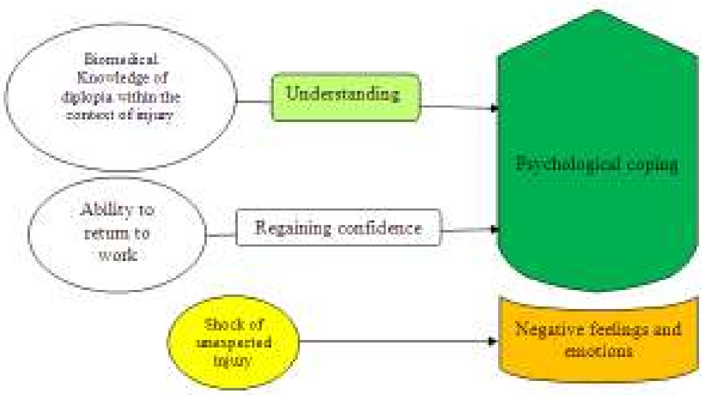

Unclear medical message
Time factor
Lack of biomedical knowledge about diplopia within the context of injury
Shock from unexpected injury
Fear and uncertainty
Loss of vision
Loss of job
Ability to drive
Results of surgery
Negative feelings and emotions

Model 1 ver. 5

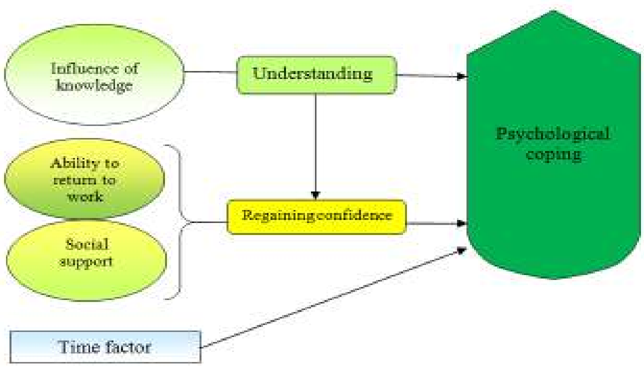
Theoretical construct for coping strategies



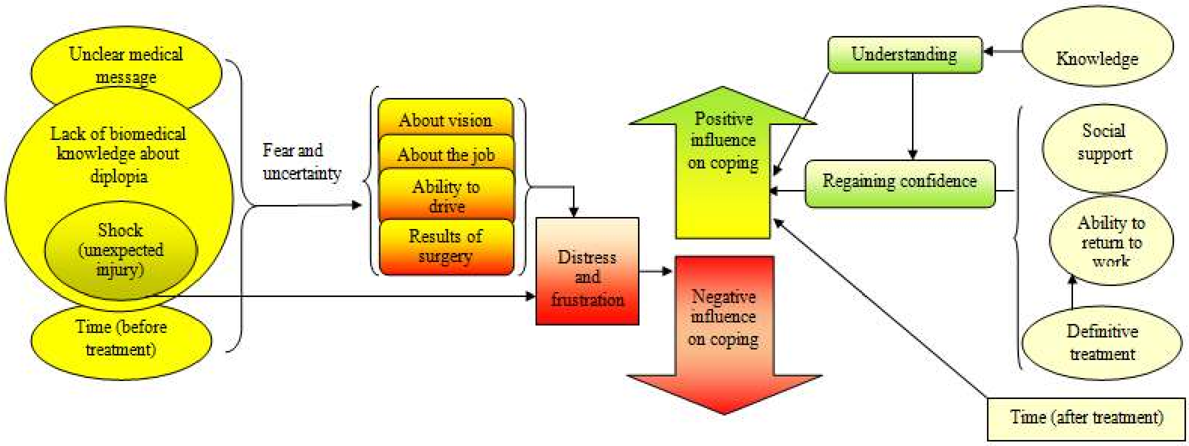
Model 2 ver.1



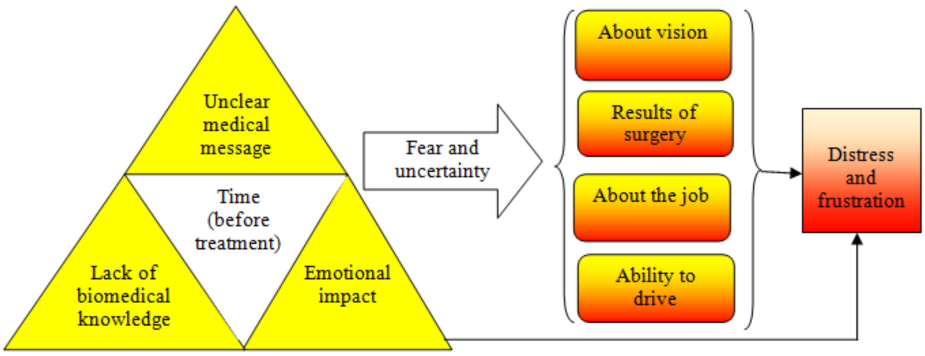
Model 2 ver.2



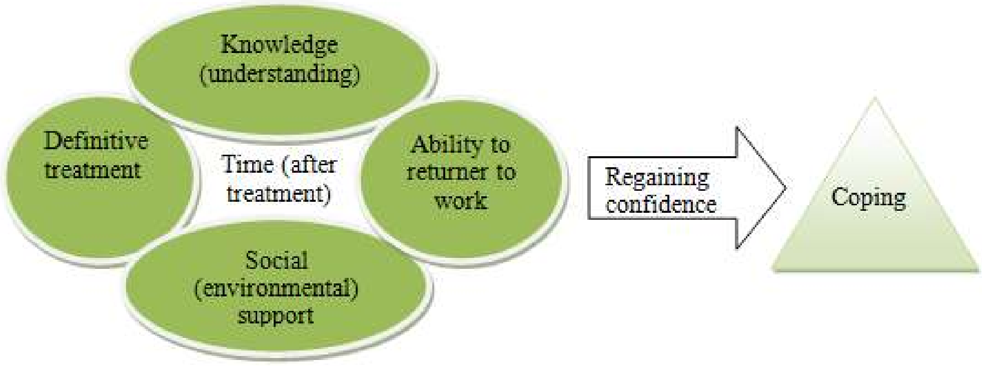
Model 2 ver.3



Theoretical model ver. 4

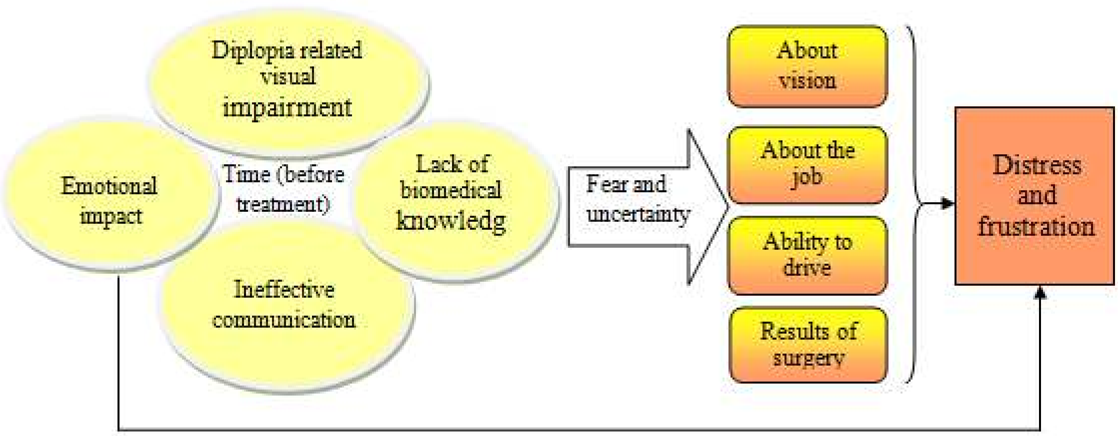


Factors negatively influence the outcome

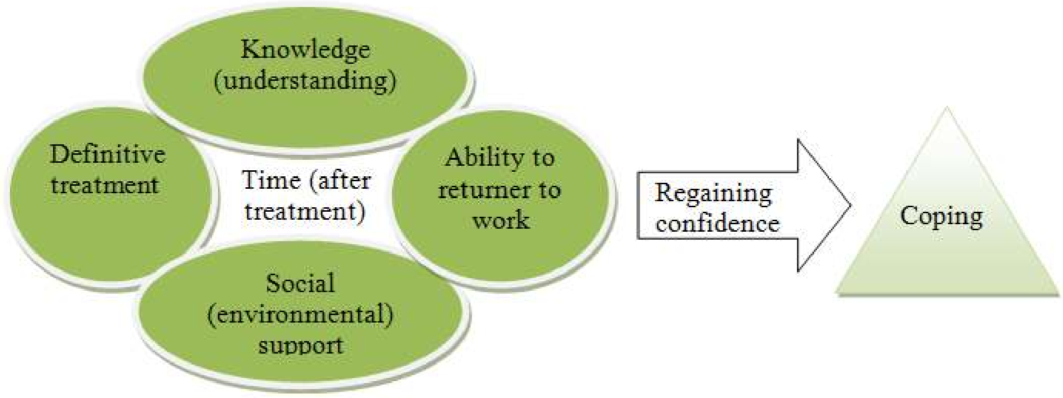


Factors positively influences the outcome

Theoretical model ver. 5



Factors negatively influence the outcome



Factors positively influence the outcome

Theoretical model ve4

2. Poster Presentation, IADR Barcelona 14-17/7/2010

Binocular Single Vision: Value in orbital blow out fractures management

Newcastle University

4840

Faaiz Alhamdani, Justin Durham , Kate Taylor and Ian Corbett*
School of Dental Sciences, Newcastle University UK. Email: f.y.alhamdani@ncl.ac.uk

aims

To explore the role of binocular single vision (BSV) measurement in the management of blow out fractures of the orbit.

Introduction

Management protocols for orbital blow-out fractures have been hampered by lack of unifying, quantitative clinical measures of severity of diplopia.
The binocular single vision (BSV) test (Evans and Fenton, 1971) is of particular interest, as it provides a simple numerical analysis of diplopia (Stocker et al, 2006, Banks, 2009) which may assist in the decision making process.

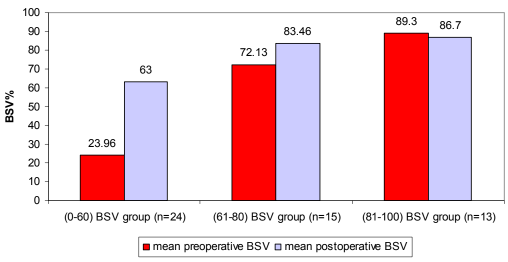
Methods

Patients undergoing orthoptic assessment for traumatic diplopia in the period 1999 -2009 were identified. Notes were hand searched for patients meeting the inclusion criteria of an isolated blow out fracture of the orbit, confirmed by CT scan, and BSV scores recorded at presentation and post-operatively when surgically managed. Data were analysed using Wilcoxon signed ranks test.

Results

Ninety eight conservatively and fifty two surgically managed patients met the inclusion criteria.
The mean BSV score at presentation for the conservative managed group was 82.7% and 58.85% for surgically managed group. The mean post-surgical BSV was 74.80%.
We stratified the surgical patients into three groups according to their pre-operative BSV, using the mean pre-operative BSV of the surgical and conservative groups as

Fig. (1) Changes in the mean BSV in surgically managed patients



Results

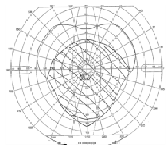


Fig. (2) BSV1 for conservatively managed patient (90%)

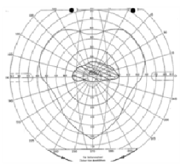


Fig. (3) Preoperative BSV (BSV1) 24%

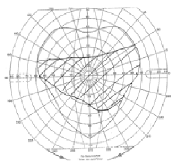


Fig. (4) Postoperative BSV (BSV2)72%

A significant increase (improvement) in BSV pre to postoperatively was recorded in patients with a preoperative BSV in the range 0-60% and 61-80% ($p<0.001$ and $p<0.05$ respectively). There was no significant increase in BSV for those in the BSV 81-100% group, with four patients having a decrease in BSV.

Discussion

It is apparent from the data that patients with low BSV scores (BSV<60%) experience the greatest improvement following surgery. Patients with a BSV score of greater than 80% demonstrate no quantifiable benefit from surgery in terms of improvement in BSV (diplopia). Pre-operative BSV may therefore be a useful guide to the likely success of surgery in improving diplopia for patients with orbital blow-out fractures. Further prospective studies are required to confirm its prognostic value.

Conclusion

We suggest that patients with a BSV≥80% should be considered for conservative management in the absence of other indications for surgery such as significant enophthalmos.

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3. Oral Presentation ABAOMS

ABAOMS Annual meeting Cardiff 2010

Free Paper Abstracts

Oral

The influence of orbital tissue herniation on diplopia and ocular motility in blow out fractures

Alhamdani F, Durham J, Corbett IP.

School of Dental Sciences, Newcastle University

ABSTRACT

Introduction:
Orbital CT scans are the most common imaging modality undertaken to aid diagnosis of orbital blow-out fractures. Extensive research has been conducted into their role in determining the influence of orbital volume change on enophthalmos, but little research has been conducted which examines the influence of orbital tissue herniation in blow out fractures on ocular motility and diplopia.

Aim of the study:
The aim of this retrospective study was to determine the influence of orbital tissue herniation, as determined by CT scan, on diplopia and ocular motility scores in blow out fracture patients.

Materials and methods:
Inclusion criteria included patients who sustained pure blow out fractures in the period 1999-2009, and for whom CT scan and orthoptic reports were available. The level of tissue herniation was determined from CT reports. Diplopia was assessed using binocular single vision scores (BSV) and ocular motility by uniocular fields of fixation (UFOF).

Results:
In the period studied, 126 patients met the inclusion criteria. Overall, there was a significant, though week, relationship between tissue herniation and both BSV score ($p<0.01$, $r=-0.30$) and UFOF score ($p<0.05$, $r=-0.27$). Further examination of this relationship revealed there to be a significant difference between the BSV and UFOF scores of injuries with no herniation and those with muscle involvement ($p<0.01$ and $p<0.05$ respectively) . However, no significant difference was observed between the BSV and UFOF scores of injuries with no tissue herniation and those with only fat herniation

Conclusion:
It is concluded that orbital muscle herniation is more influential than fat herniation on diplopia and ocular motility in blow out fractures. We suggest that orbital fat herniation alone may not be an adequate indication for surgical intervention.

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4. Work in progres

a) Drafts of papers

(1) The influence of tissue herniation on diplopia and ocular motility in orbital blow out fractures; a 10 year retrospective study

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ABSTRACT

Introduction

Orbital CT scans are the most common imaging modality undertaken to help diagnose an orbital blow-out fracture. Extensive research has been conducted into their role in determining the influence of orbital volume change on enophthalmos, however, no research has been conducted which examines the influence of the herniated tissue on ocular motility and diplopia.

Aim of the study

The aim of the study is to determine the effect of orbital tissue herniation, as determined by CT scan, on diplopia and ocular motility scores in blow-out fracture patients.

Materials and methods

Patients who sustained pure orbital blow out fractures in the period 1999-2009, and for whom CT scan reports were available were included in the study. Three levels of tissue herniation were reported; none, fat only, and fat and muscle. Orthoptic assessment included binocular single vision (BSV) and uniocular fields of fixation (UFOF) scores.

Results

123 patients were included in the study. Although mean BSV and UFOF scores decrease with increasing amounts of tissue prolapse, there was no significant difference between the BSV, UFOF scores of injuries with no tissue prolapse and those with only fat herniation ($p>0.05$). A significant difference was noted between the BSV and UFOF scores of no/fat herniation and injuries with fat and muscle prolapse groups. Patients with muscle herniation had a tendency for an unfavourable outcome following surgical intervention.

Conclusion

We suggest that orbital fat herniation may not be an adequate indication for surgical intervention for correction of diplopia in orbital blow out fractures. Cases with orbital muscle herniation are more

likely to be have an unfavourable outcome in relation to diplopia.

Introduction

Ocular motility disturbance in blow out fractures is a multi-factorial phenomenon [1] [2]. However, It is believed that orbital soft tissue involvement in the fracture defect is an important influential factor on ocular motility in this type of injury [3] [4] [5]. Despite this belief, the subject has received little attention.

Gilbard *et al* classified the pattern of inferior rectus muscle entrapment in orbital floor fractures into 3 categories; free from entrapment, hooked, and entrapped. They stated that patients with CT scan evidence of bone fragments adjacent to the inferior rectus muscle on both sides have a high risk for developing diplopia, while CT scan evidence of hooked muscles, or the inferior rectus muscle adjacent to a bone fragment on one side only, had less diplopia, and those with free inferior rectus muscles had no diplopia [4].

Totsuka and Koide using an animated MRI study, suggested incarcerated connective tissue septa, as described by Koornneef 1982 [6], to be the main cause of motility problem in blow-out fractures. They believed that incarcerated septa at the fracture site cause restricted eye movement through their interference with the contraction and relaxation of the external ocular muscles [7].

Furuta *et al* studied the number of points of muscle contact with orbital fractures on CT along with Hess Area Ratio (HAR) for measurement of extraocular muscle function. They analysed 113 cases of blow out fracture with diplopia and found that both clinical manifestation and prognosis could be approximately predicted on the basis of number of muscle contact points related to the fracture margin. Furthermore, they stated that treatment option should rely mainly on thorough evaluation of CT scan [8].

Harris et al ref postulated that soft tissue damage and subsequent diplopia was related to the level of tissue involvement and bony fragment distraction shown in preoperative CT scan studies [5]. However, this study had limitations: They applied six criteria (2 types and 3 subtypes) on 30 patients, which resulted in low number of cases for each subdivision, reducing the statistical value of their findings. The authors also did not provide preoperative ocular motility measurements for their cases [9].

The paucity of studies that discussed the influence of orbital tissue involvement on ocular motility in blow out fractures, made their findings inconclusive [10]. Reliance on subjective criteria to describe ocular motility and diplopia might be one reason. [11] In addition, the fact that surgeons might be more concerned about spotting the site and the type of fracture rather than the degree of tissue involvement in it may also be of relevance.

Measurement of binocular single vision (BSV), using a Goldman Perimeter has been suggested for routine evaluation of diplopia assessment of orbital trauma patients by several authors [12] [13] [14, 15], providing a simple, reliable method for quantifying diplopia [16] It has been recommended ,. Uniocular field of fixation (UFOF) measurement of ocular motility has similarly been recommended for objective recording of eye movement. Unlike Hess charts [17], it provides a numerical score for the six extraocular muscles for each globe [18]. The relationship between BSV and ocular motility scores has not previously been reported.

Aim of the study

The aim of the current investigation was to determine the effect of orbital tissue herniation, as determined by CT scan, on diplopia and ocular motility scores in blow out fracture patients

Materials and Methods

Patients with orbital blow out fractures were identified form orthoptic records of the host institution for the ten year period January 1999 to December 2009 inclusive. Patient records were obtained and hand searched for the following information.

1. Demographic data
2. Dates of attendance
3. Clinical findings
4. Ophthalmology examination
5. Radiology findings
6. Orthoptic assessment
7. diplopia outcome in surgically managed group

The inclusion criteria for this study were as follows: Patients who had sustained an isolated orbital blow out fractures during the 10 year period, for whom CT scan reports were available.

For the purpose of statistical analysis, the level of orbital tissue herniation was divided according to CT scan reports into 3 levels; zero level for cases with no evidence of soft tissue herniation; level one for cases with orbital fat herniation; level 2 for cases with orbital fat and muscle prolapse into the fracture defect. This categorisation was the most frequently applied by the reporting radiologists throughout the study period. Cases with orbital muscle entrapment were excluded from our sample, as entrapment represents a different mechanism of tissue involvement. Entrapment was uncommon in our sample, with only 2 cases were identified.

Orthoptic data included:

1- Binocular Single Vision (BSV) scores for diplopia measurement. Scores range from 0 (diplopia in positional fields) to 100 (no diplopia)(ref Kates paper here)
2- Uniocular Field of Fixation (UFOF) scores for ocular motility measurement. Scores range from 60 -365. UFOF scores for both normal and injured sides were documented. Ocular motility was recorded as a percentage maximum achievable score.

Surgical outcome in relation to diplopia was subjectively divided according to the orthoptic report at the final patient visit into 4 groups. In this report the orthoptist describes the patient comments and perception about their double vision after surgery. In this coding process, the term “asymptomatic” was used for the first group of patients who have no complaint of diplopia; the second group are patients who were “not concerned about” any residual diplopia; “symptomatic” for the third group of patients who had residual diplopia in fields of gaze and finally the forth group of patients who needed further measures, such as prism glasses or strabismus surgery, to correct disabling diplopia.

Data analysis was performed in SPSS (ref ver.17) using Wilcoxon signed ranks, Pearson, Spearman and Chi-square tests.

Results

Of 257 patients identified, 123 patients met the inclusion criteria. BSV scores were obtained for 104 cases. UFOF scores were available for 63 cases. Follow up data was available for 48 patients. All patients were managed in the Oral and Maxillofacial Department, Newcastle General Hospital.

The time range for patients' examinations and treatment is shown in Table 1.

Table 5: Descriptive statistics for timeline of patient management

Time, days	Minimum	Maximum	Mean	median
Between injury and clinical presentation	1	37	6.8	4.5
Between injury and orthoptic examination	1	547	19.45	8
Between injury and surgery	1	540	23.5	14
Between surgery and postop. orthoptic examination	8	150	44.6	36.5

Sixty seven patients (54.9%) had injuries to the left orbit, and 54 cases (44.3%) right. One patient presented with bilateral blow out fractures. Males represent 71.4% of the cases, whilst females represent 28.6%. The age range in this case series was 5-79 years, mean 33.73. A Spearman correlation test showed no influence of patients' age on the level of orbital tissue herniation.

Isolated orbital floor fracture was the most common type of injury, affecting 91 patients (74%) of the cases. Seven patients (5.7%) reported with medial wall blow out fracture only and 25 patients (20.3%) combined floor and medial wall fractures. Orbital fat herniation occurred most frequently in this sample (48%). Cases with no tissue herniation represent the smallest group (12.8%) (Figure 1).

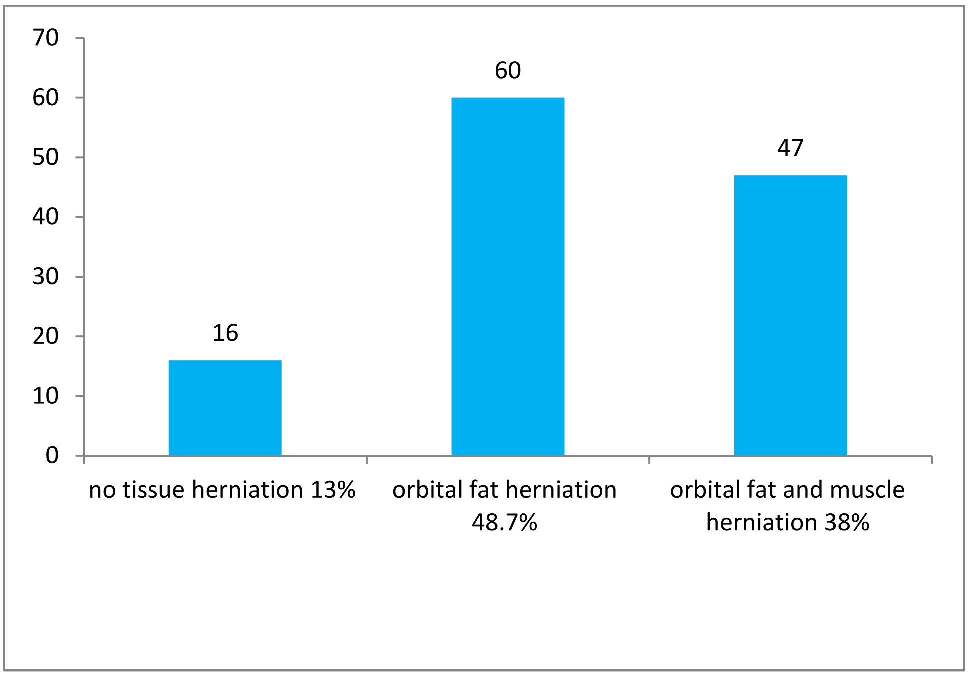

Figure 5. Percentage of cases for each level of tissue herniation.

Our data showed no significant relationship ($p>0.05$) between the type of injury or side of injury and the level of tissue herniation (Chi-square test).

Forty nine patients underwent surgery and 74 patients were treated conservatively. When comparing surgically managed with conservatively managed groups, a similar incidence of orbital fat involvement was noted, approximately 50% of cases. As may be predicted, conservatively managed patients were twice as likely to have no apparent tissue herniation in the fracture line (Figure 2), whereas the majority of the surgical group (87%) reported with muscle herniation. The significance ($p<0.05$) of difference between the two management groups in the level of herniation has been statistically confirmed (Mann-Whitney U test).

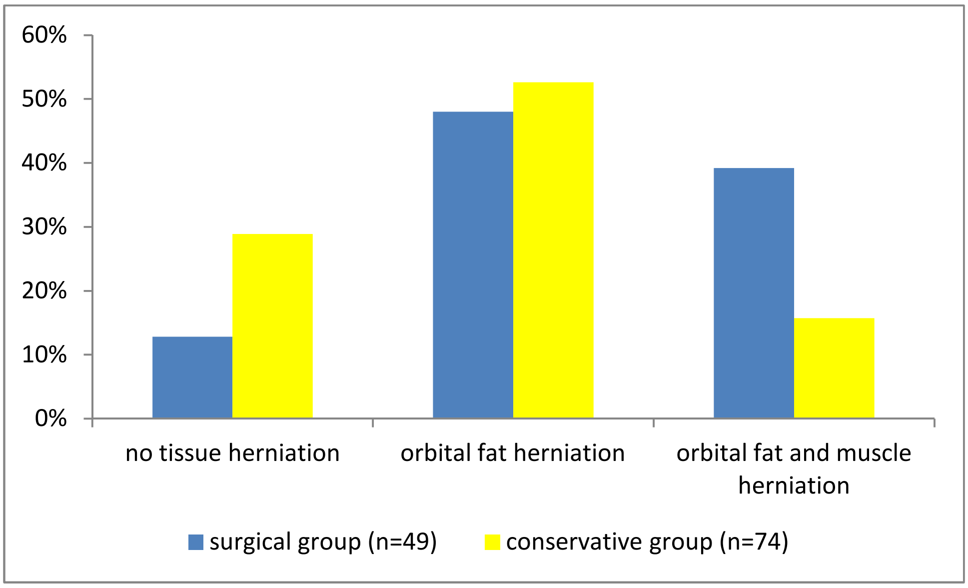

Figure 6. Level of tissue herniation for surgically and conservatively managed groups

Figure 3 and figure 4 illustratse the negative relationship between tissue herniation level and both mean BSV and UFOF scores. This relationship has been statistically confirmed (p<0.05, r=-0.30 and p=0.05, r=-0.27 respectively).

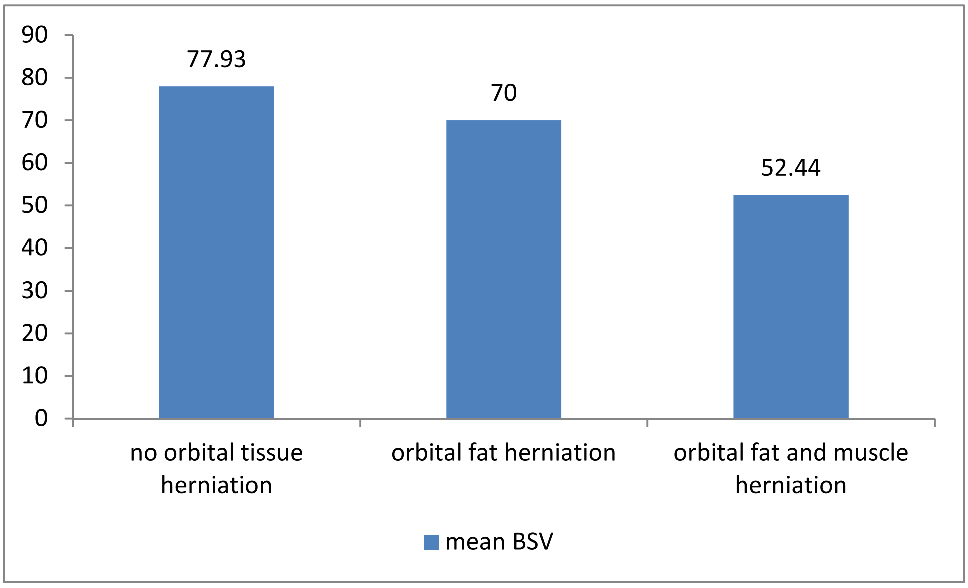

Figure 7. Mean BSV (n=104) for the 3 levels of orbital tissue herniation for the whole retrospective sample.

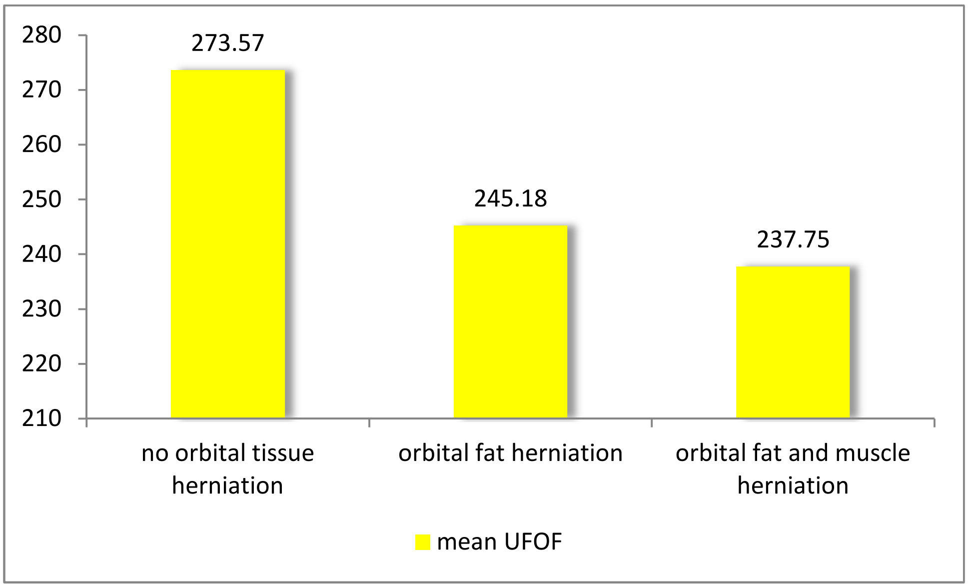

Figure 8. Mean UFOF (n=63) for the 3 levels of orbital tissue herniation for the whole retrospective sample.

Table 2 shows that mean BSV scores in cases with "no orbital tissue herniation" and cases with "orbital fat herniation" are similar in each management category. On the other hand the mean BSV scores for "orbital muscle herniation" are different from the mean BSV scores in both "no tissue herniation" and "orbital orbital tissue herniation".

Table 6: Mean BSV scores for each level of herniation by management groups

Level of tissue herniation	**Mean BSV Surgical group**	**Mean BSV Conservative group**
No herniation	59	84
Orbital fat herniation	59	85
Orbital muscle herniation	45	91

Mann-Whitney test showed no significant difference (p>0.05) for both BSV and UFOF scores between cases with "no tissue herniation" and "orbital fat herniation". Whereas there was significant difference for both BSV and UFOF scores between "no tissue herniation" and "orbital muscle herniation" cases.

The relationship between the level of tissue herniation and the postoperative diplopia outcome was not significant (p>0.05). However, 70.5% of cases with orbital fat herniation were within the "asymptomatic" and "not concerned" categories, which could be considered favourable outcomes, whereas 58% of the cases with orbital muscle herniation lay within the "symptomatic" and "required other measures" categories, i.e. unfavourable outcomes (Figure 4),.

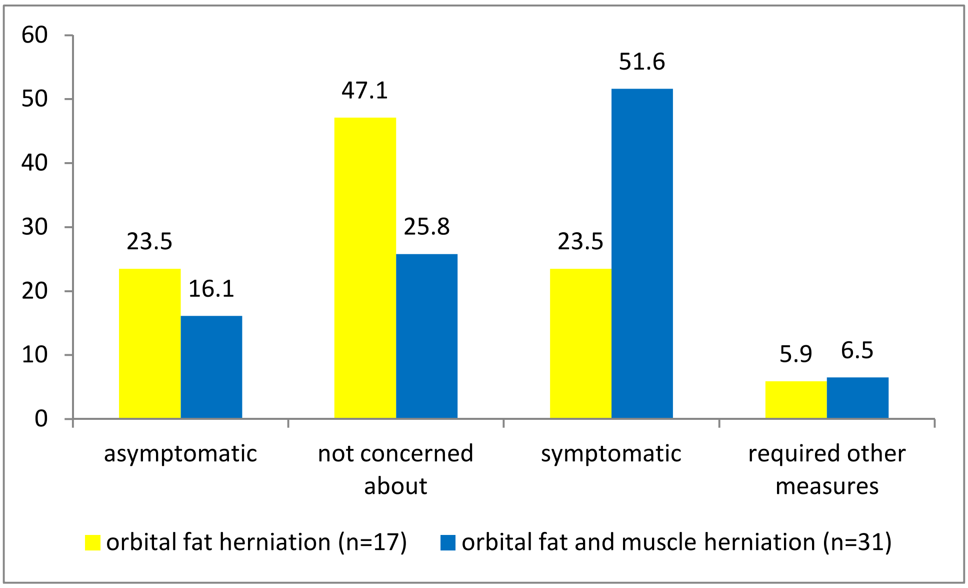

Figure 9. Final outcome by the level of herniation.

Discussion

Our finding that orbital fat herniation was the most common reported level of tissue herniation, agrees with the finding of Sleep *et al* [19]. Entrapment of extraocular muscles was uncommon this retrospective sample and is in keeping with previous studies. [20] [21] [22] [23]

To the best of our knowledge, the influence of orbital tissue herniation level on diplopia (BSV score) and ocular motility (UFOF score) has not been reported in the literature. Our data showed that orbital tissue herniation has a negative influence on both ocular motility and diplopia. Correlation coefficient values, however, indicate that this influence is not a considerable one. Thus factors other than tissue herniation are likely to play an important role in ocular motility problems in blow out fractures. Koornneef stated that incarceration of orbital tissue is not responsible for severe ocular motility problems, rather a dysfunction of the entire motility apparatus in the fracture region [6]. Weak correlation between tissue herniation and diplopia could be also explained by the fact that diplopia and ocular motility scores in "fat herniation" cases, which constitute about half of the cases, were not significantly different from the "no tissue herniation" level.

The level of tissue herniation was not previously included within the criteria for surgical management. The absence of significant difference in diplopia and ocular motility scores between "no tissue herniation" and "orbital fat herniation" levels, as well as the fact that cases with orbital fat herniation have almost the same prevalence in both management groups, raises the question of the value of considering orbital fat herniation in surgical intervention in blow out fractures.

Despite the fact that tissue herniation level has no statistical influence on the surgical diplopia outcome categories, our data showed that cases with orbital muscle herniation are more likely to have an unfavourable diplopia outcome. Harris *et al* believe that more tissue involved in the fracture, the more likely to there is to be ocular muscle injury, which negatively affects the motility outcome. [5] , Indeed, it may be tissue injury rather than tissue herniation that is important in diplopia arising from orbital fractures.

As with all retrospective studies, problems arose with missing data, in particular orthoptic follow up data for the conservative group. This prevented comparison of diplopia outcomes for each level of tissue herniation in both management categories.

Conclusion

It is concluded that orbital fat herniation has no significant influence compared to “no tissue herniation” on diplopia in blow out fractures.

We suggest that orbital fat herniation may not be an adequate indication for surgical intervention for diplopia correction.

Cases with orbital muscle herniation are more likely to be at risk of unfavourable outcome in relation to diplopia.

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(2) Factors influencing diplopia outcome in orbital blow out fractures' surgery

10 year (1999-2009) retrospective study

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Institution: School of Dental Sciences, Newcastle University

Abstract

Introduction

There is no general consensus regarding management of blow out fractures of the orbit. This might be the reason behind the fact that surgical outcome in terms of ocular motility, in the last two decades, has been less than satifactory.

It is hypothesized that lack of unifying quantitative clinical measures for the level of diplopia in the literature has hampered the management of blow out injury of the orbit and played a role in the management controversy.

Aim of the study

To study diplopia (BSV) and ocular motility (UFOF) characteristics in blow out fractures of the orbit and their value in blow out fracture management.

To relate the current management practice for blow out fractures within Newcastle General Hospital Oral and Maxillofacial surgical unit to surgical outcome measures.

Materials and Methods

Patients with isolated blow out fractures treated (1999-2009) and their preoperative and postoperative BSV scores are available, were included.

BSV scores were stratified into 3 categories: low BSV category (0-60); mid BSV category (61-80) and high BSV category (81-100). UFOF score also divided into 3 categories low score (60-240), mid score (241-270) and high score (271-365) categories. This categorisation relied on the median BSV and UFOF scores for both surgically and conservatively managed patients.

Results

Eighty seven patients (70 from the surgical group and 17 from the conservative group) met the inclusion criteria.

There was no significant improvement in high BSV category in the surgical group, whereas there was significant improvement ($p<0.05$) for the high BSV category in the conservative group.

Preoperative BSV was found significantly related ($p<0.05$) to postoperative BSV, subjective diplopia outcome, follow up time and number of follow up visits. However, improvement of BSV score in surgical group was not found significantly correlated with subjective outcome in relation to diplopia.

Preoperative UOFO score has been found significantly related to the number of follow up visit. However, it has no influence on subjective outcome in relation to diplopia.

Surgical timing, approach and the choice of implant material were not found statistically related to

final diplopia outcome, the follow up time, and the number of follow up visits.

Conclusions

Binocular single vision (BSV) has more influence than unicular field of fixation (UFOF) on diplopia outcome, follow up time and number of follow up visits. On the basis of this study, surgical intervention would not be recommended for blow out fracture cases with BSV score >80% for correction of diplopia alone.

Introduction

Management of isolated orbital blow-out fractures remains a topic of controversy. General consensus suggests surgical intervention in cases of persistent diplopia, enophthalmos, or large size defects which may result in late enophthalmos [1]. However, the criteria for diplopia as an indication for surgery described in the literature is predominantly subjective, for example; 'persistent 'troublesome' diplopia', 'severe', 'visually handicapping diplopia.' [2] [3] [4] [5])

Conversely, enophthalmos has more objective management criteria, with intervention suggested for enophthalmos of 2 mm or more, fracture size greater than 2 cm² or more than 50% [6] [7] [8] [9] [10]. In addition, it is generally accepted that when surgical intervention is indicated, early intervention, as far as patient's condition permits, is advocated. Such general protocols have been adopted in many recent clinical studies investigating the evaluation and treatment of blow out fracture [11] [12] [13] [14] [15] [16] [10] [17].

Despite the fairly agreed management protocol, surgical outcome, in terms of ocular motility and diplopia, in the last two decades has been less than ideal [18], with persistent postoperative diplopia frequently reported [5] [15].

Ocular motility disturbances in orbital injuries are usually assessed by Hess chart. The reliance of orbital trauma studies on Hess chart only, makes diplopia subjectively represented and difficult to evaluate [19].

Attempts have been made at quantifying Hess charts [20, 21], although not been adopted. Furuta *et al* [21] used Hess Area Ratio (HAR) measurement to express the ocular motility in numerical values by comparing the Hess chart between the affected and healthy side and they found that, of the patients with HAR% > 85%, most experienced no diplopia.

It is hypothesized that lack of unifying quantitative clinical measures for the assessment of diplopia [22] [23] [24] [25] [15] [26] [17] [16] [5] has hampered progression in the management of blow-out injury of the orbit.

Diplopia' and 'ocular motility disturbance', as terms, have been used frequently in orbital fracture studies interchangeably [27] [14] [16]. This could be explained by the fact that diplopia being a clinical manifestation of ocular motility disturbance.

For the measurement of diplopia, binocular single vision test on Goldmann Perimeter has been recommended for routine evaluation of orbital trauma patients by several authors, as it is a simple reliable method for quantifying diplopia [28] [29] [30], [31].

Unicular Field of Fixation test (UFOF) provides a quantitative assessment of ocular motility, as the primary field of action of each of the six individual ocular muscles is plotted on Goldmann perimeter [32]. This test has been used in ocular motility assessment for Graves Ophthalmology patients in different methods [33] [34] [32]. However, it has not been reported on orbital trauma patients before.

Aim of the study

The aim of this retrospective study is to investigate the value of two objective measures, binocular single vision (BSV) and unioccular fields of fixation (UFOF) in the management of blow out fractures of the orbit. In addition, the study aims to relate the current management practice for blow out fractures within this unit to surgical outcome measures.

Materials and methods

Patients' data in held in the Orthoptic Department, Royal Victoria Infirmary, Newcastle upon Tyne was tracked back to 1999. Patients' notes were hand searched for the following information.

1. Demographic information
2. Date of injury
3. Date of orthoptic examination
4. Date of surgery
5. Clinical findings
6. Ophthalmology examination
7. Pre and post-operative orthoptic assessment, including BSV and UFOF scores.
8. Follow up visits.

Inclusion criteria: Patients who had a CT scan-confirmed blow out fracture, involving orbital floor and/or medial wall, whom were managed surgically or conservatively, in the period 1999-2009 inclusive, with recorded preoperative and postoperative BSV scores available. Exclusion criteria: Patients who sustained orbital fractures involving orbital margins identified pre- or peri-operatively.

Orthoptic examinations included weighted BSV [35] and UFOF tests for both affected and unaffected sides. UFOF scores were taken as the sum score for the 6 extraocular muscles [32]. Most patients who underwent surgery had a minimum of two BSV measurements performed by an orthoptist. One was taken shortly after presentation and the other postoperatively. At the time of the first orthoptic examination patients were also examined by an ophthalmologist. For the majority of conservatively managed patients, one orthoptic examination was performed.

For statistical analysis BSV scores were stratified into 3 categories: low BSV category (0-60); moderate BSV category (61-80) and high BSV category (81-100). UFOF scores were similarly stratified into low score (60-240), moderate score (241-270) and high score (271-365) categories. This categorisation relied on the median BSV and UFOF scores for both the surgically and conservatively managed population. Median has been chosen to represent the central tendency because of the wide range of BSV observed for both surgical and conservative group.

A subjective assessment of diplopia at the final orthoptic review was also recorded. This outcome divided according to the orthoptists comments into 4 categories; asymptomatic, not concerned by diplopia, symptomatic and requiring further measures. Further measures included provision of prism glasses and strabismus surgery.

Collected data were analysed using SPSS ver.17. Statistical relations were examined with Wilcoxon signed ranks test, Pearson, Chi-square and Spearman tests.

Results

Of 391 patients identified from the orthoptic database, 259 patients were recorded as having isolated blow out fractures. Surgery was performed for 152 patients, leaving 107 patients who were conservatively managed. However, only 87 patients (70 from the surgical group and 17 from the conservative group) met the inclusion criteria, predominantly due to a failure to record data correctly in the patient records. Failure of records, also, affected available follow up data of surgical group patients. Out of 87 patients, 56 patients from the surgical group whom their complete follow up data are available.

The patients ranged from 9 to 80 years of age, with a median of 35 years, of which 19 patients were females, while 68 were males. Timeline for patients' management and orthoptic data are shown in table 1 and 2.

As shown in figure 1, diplopia was the most common presenting complaint, with a low incidence of enophthalmos at presentation in this group. Reported ophthalmic injuries included corneal abrasion, conjunctival chemosis, hyphema, traumatic mydriasis, peripheral retinal haemorrhage, and commotio retinae.

Table 1 shows the timeline of patient management. More than half of the surgical cases were treated within the first 2 weeks of the injury (Figure 11). Only 12.5% were treated more than one month after the injury.

The median BSV1 for the surgical group was 59.5%, while the median BSV1 for the conservative group was 86% (Table 8). Preoperative BSV (BSV1) was found significantly related ($p<0.001$) to BSV2. Also, there was a highly significant relationship ($p<0.001$) between UFOF1 and both BSV1 and BSV2.

There was significant difference between preoperative and postoperative BSV scores in both low and middle BSV categories ($p<0.001$ and $p<0.05$ respectively) in the surgical group. The high BSV category, however, showed no significant ($p>0.05$) change. In contrast, there was significant difference ($p<0.05$) in BSV score for the high BSV category (n=11) in the conservative group (paired t-test) (Figure 12, Figure 13).

The surgical approach for the vast majority of the cases was the 1st skin crease incision. Conjunctival approach was the least (less than 2% of the cases) used approach in this sample (Figure 14). Silastic sheet was the most common implant material, followed by titanium mesh. Bone graft on the other hand used in less than 5% of the cases. Only two cases were managed without placement of implant material (Figure 15). Surgical timing and implant material choice were not significantly related ($p>0.05$) with postoperative BSV (BSV2) score.

More than half of the cases reported with symptomatic diplopia outcome (Figure 16). These cases showed variable degree of improvement, although residual diplopia was present in one or more than one field of gaze. There is a negative relationship ($p<0.05$) between BSV1 score and the final diplopia outcome categories (Figure 17). BSV1 also found statistically ($p<0.01$) related to the follow up time and number of the follow up visits.

The level of improvement in BSV score has been, also, found significantly related ($p < 0.05$) to the follow up time. However, BSV improvement has not been found to be significantly related ($p> 0.05$) to the subjective outcome in relation to diplopia.

A significant relationship, also, was found between UFOF1 and the number of follow up visits ($p<0.05$). However there was no significant relationship ($p>0.05$) between UFOF1 and the final diplopia outcome and the follow up time for the surgical group.

The surgical timing and the choice of implant material have not been found significantly related ($p>0.05$) to the BSV score improvement, subjective diplopia outcome, follow up time and the number of follow up visits.

study variable	Minimum	Maximum	Mean	median
Age of patient	9	80	36.33	35
Time from injury to presentation (surgical group)	1	37	7.36	4
Time from injury to orthoptic	1	60	12.55	8
Time from injury to surgery	1	134	18.84	14
Time from Surgery to postop. orthoptic	14	130	43.93	36
Follow up time (months)	0.5	15	5	3
Number of follow up visits	1	7	2.25	1

Table 13 Timeline for patients

Orthoptic data	Minimum	Maximum	Mean	Meadian
UFOF normal side	202	342	282.98	281.5
BSV1 surgical group	0	97	48.84	59.5
UFOF1 surgical group	61	334	234.14	237
BSV1 conservative group	0	100	72.65	86
UFOF1 conservative group	191	319	260.5	262

Table 8 Descriptive statistics for orthoptic data

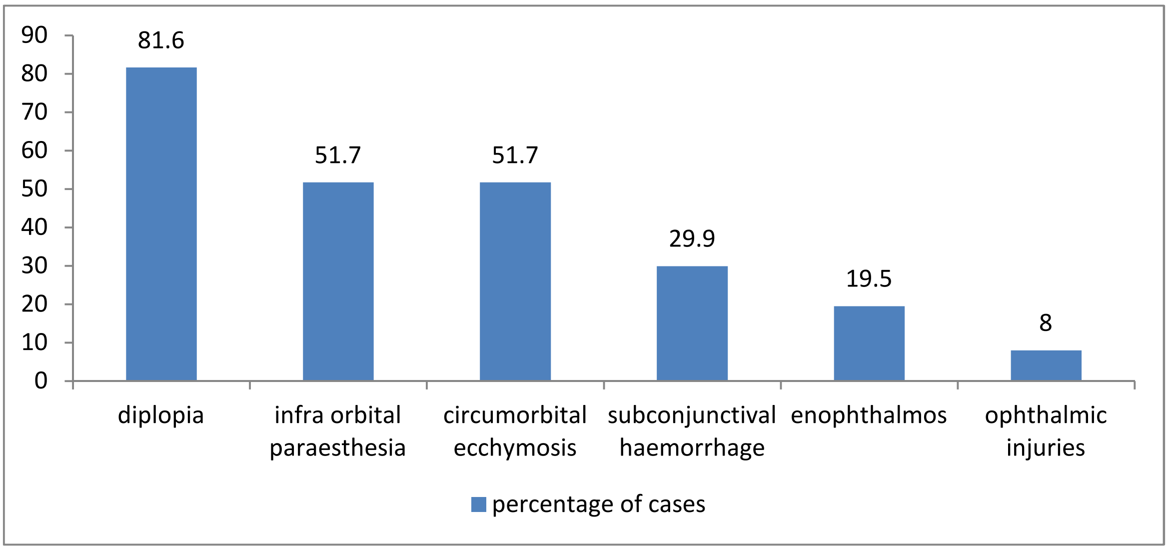


Figure 51 the clinical features

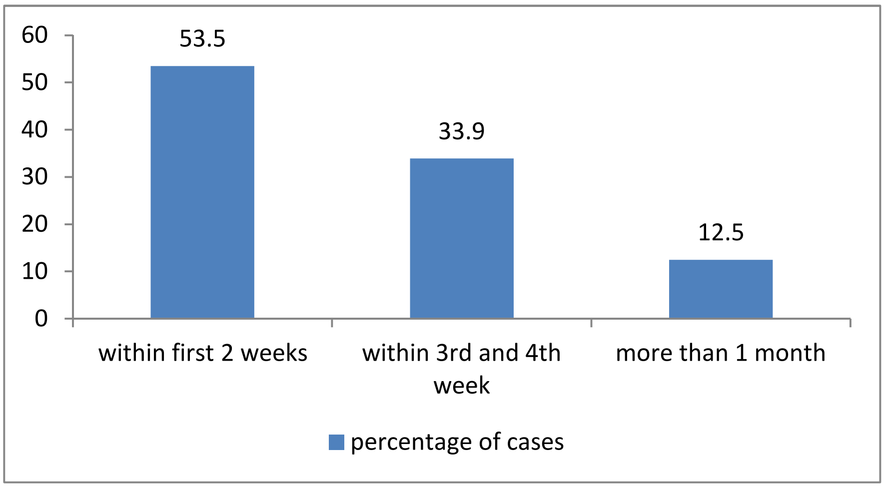


Figure 11 surgical timing

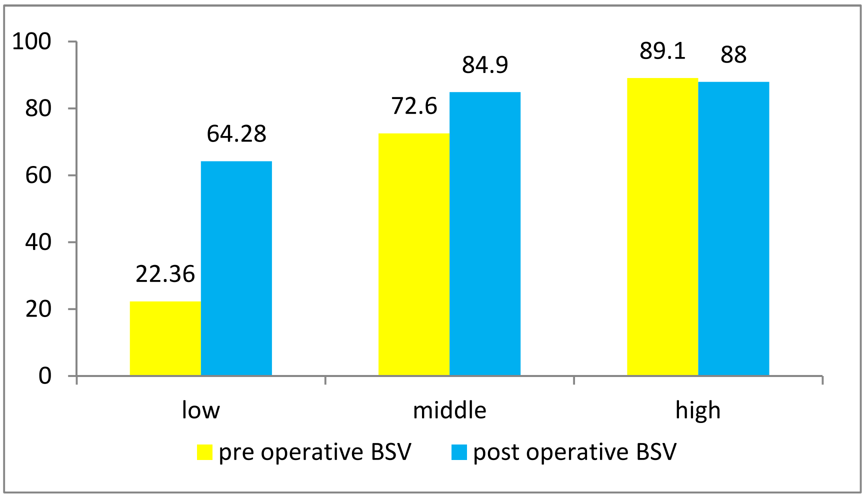
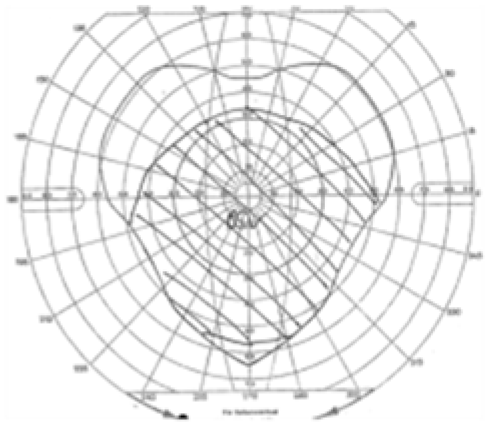
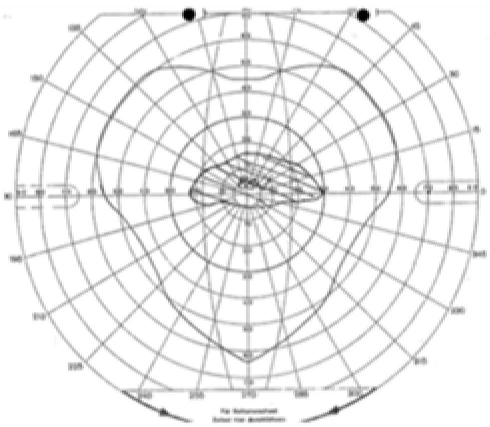
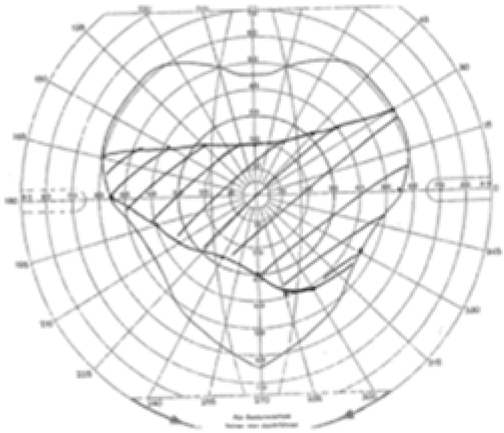


Figure 12 changes in the means of BSV categories for surgical group



(a) BSV1 (90%) for conservatively managed patient





(b) BSV1 (24%) for surgically managed patient (c) BSV2 (72%) for the same patient

Figure 13 BSV scores for conservatively and surgically managed patients

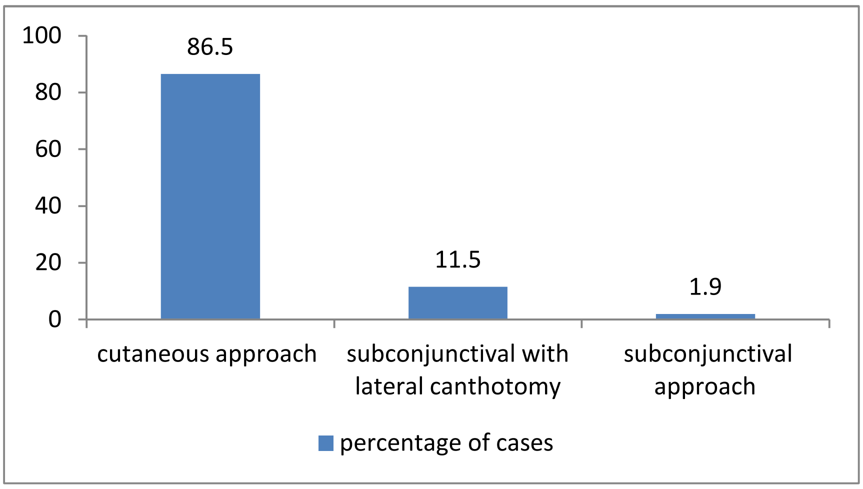


Figure 14 surgical approach

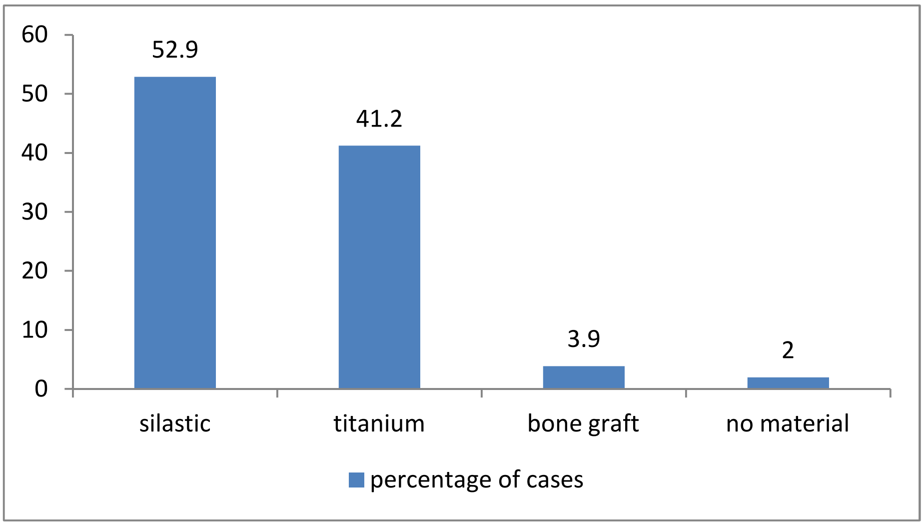


Figure 15 implant materials

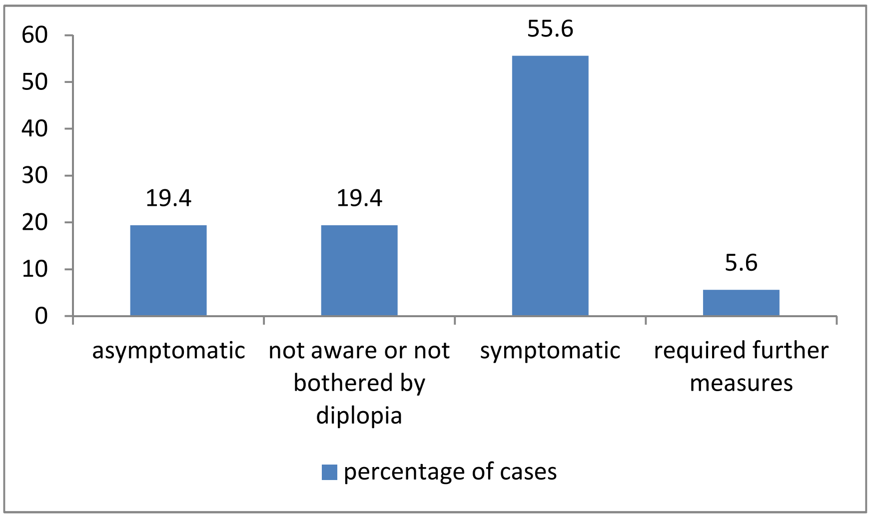


Figure 16 final outcome categories in relation to diplopia

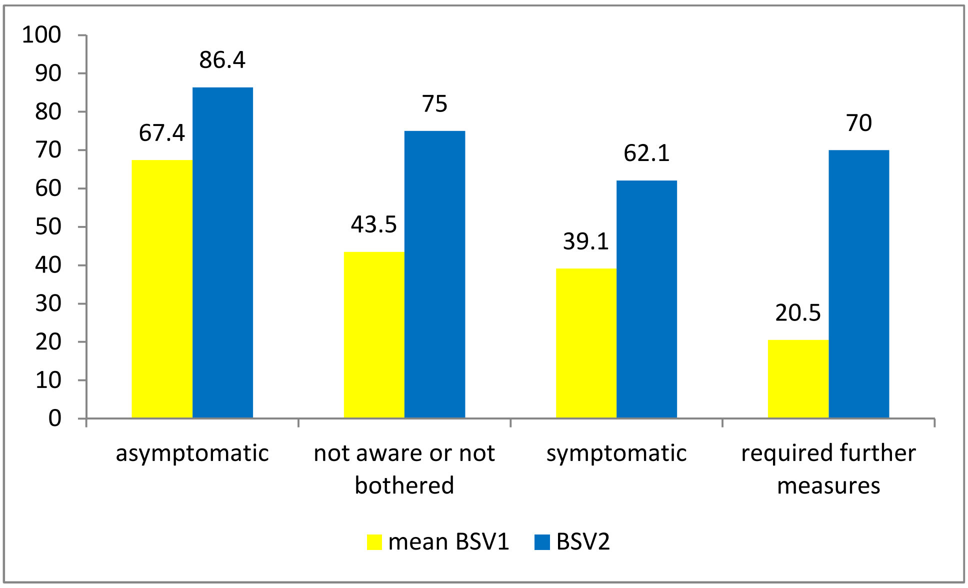


Figure 17 mean BSV1 and BSV2 for each diplopia outcome category

Discussion

BSV measurement, using a Goldman Perimeter, has been suggested as the 'gold standard' for diplopia assessment [36]. It has been recommended for routine evaluation of orbital trauma patients by several authors, as it is a simple reliable method for quantifying diplopia [28] [29] [30] [31]. Despite such reports, BSV has not been reported routinely in the literature. The UFOF test is not routinely done in the orthoptic department. It has been found, however, that UFOF scores correlate with both preoperative and postoperative BSV and the number of follow up visits. UFOF has not previously been reported in orbital trauma studies.

Within this Oral and Maxillofacial unit, the need for surgical intervention has essentially been subjective, based on persistent diplopia, with a fracture confirmed on CT. Baseline orthoptic examination have been used to support the clinical decision rather than as an indicator of need for surgery. From our data it is be suggested that BSV score thresholds may be of value in determining the need for treatment. Surgical patients within the high BSV score category (BSV> 80%), demonstrated no overall improvement in terms of postoperative BSV scores. Conservative group patients within the same BSV score category, however, showed significant improvement.

Timing for blow out fractures surgery is one of the debated issues [37]. Some surgeons advocate early surgery to avoid fibrosis and permanent disability of the involved muscle in the fracture defect [38] [39] [40]. Conversely, others argue that time should be given to allow resolution of haemorrhage and oedema [41], [42], [43], [9] [3].

Although there is general consensus that delay of surgery is not advisable, there is a disagreement about what constitutes delay, with early management ranging between 1 week [40], 10 days [39] [44], 2 weeks [15] [45] [3], 3 weeks [41] [46] [13] [8], to 2 months of injury [47]. Hinohira *et al* although not advocating delay in surgery, found that ocular motility disturbances could be corrected even 3 months after trauma [48].

In the current study the vast majority of the cases were treated within 30 days from the injury and more than half within 14 days, which is a widely adopted time frame [15] [45] [3].

Timing of surgery was not found to have an influence on BSV2, the reported final diplopia outcome or the number of the follow up visits. Jin *et al* (2007) also found that surgical timing was not statistically related to postoperative diplopia. They considered surgical timing to be crucial in cases with trapdoor fractures with extraocular muscles entrapment [49]. However, this disagrees with Hossal and Beatty (2002) who found significant relation between timing of surgery and postoperative diplopia [15]. The reason for this disagreement might be attributed to the difference in the subjective criteria for diplopia. This confirms the need for unifying quantitative measurement criteria for diplopia. Putterman (1991) believes that orbital surgery after 5 weeks unlikely improve the ocular motility disturbances. For such cases he advised extraocular muscle surgery [8].

In this case series, orthoptic follow up time exceeded one year for some cases (up to 7 postoperative visits), dictated by the level of diplopia and resolution. The mean/median follow was 5/3 months respectively, with the majority of surgical patients having 1visit(s). Studies published to date have reported variable postoperative follow up periods, with little agreement as to a follow up protocols, Orgel (1971) suggesting review on a monthly basis. However, he did not point out the follow up end point [41]. Hosal and Beatty (2002) found that diplopia improved 1-4 weeks in 80% of their cases [15]. Sleep *et al* (2007) believe that this type of fracture is usually associated with delayed recovery, over 6 months persistent diplopia. They reported (1-7) months as a time range for the resolution of postoperative diplopia, with mean of 4.4 months [26]. Other studies gave a range of follow up from 3 months to 4 years [49]. In their case series Poeschl *et al* [50] reported 1-14 months follow period with 3 months mean. The absence of a unified follow up period and timetable might be explained by the fact that ocular motility disturbance continues to improve for up to 9 months Gosse *et al* [3].

Interestingly, our data showed that there was no significant influence of BSV improvement over the subjective diplopia outcome, despite the functional scoring criteria [35] adopted in this study. The absence of significant relation between BSV improvement and subjective diplopia outcome might be explained by the fact cases with low BSV1 could still end up with a moderate BSV2, despite the obvious improvement in BSV score. Whereas, cases high BSV1 with little improvement will still have high BSV2.

Management controversy in blow out fractures of the orbit has been attributed to the absence of clear criteria for surgical versus conservative managements [51], a reflect of personal preference [44], and multi disciplinary intervention [52].

it should be considered however, that surgery does not address direct extraocular muscle injury [53], indeed, muscle injury may occur during surgical manipulation [54]. Iliff *et al* stated that close proximity of inferior rectus muscle to the orbital floor in posterior orbit makes it more susceptible to contusion after fracture. In the anterior half of the orbit the extraocular muscles are protected by a cushion of extramuscular fat [53]. Stocker *et al* found that patients with posterior blow out fractures, generally, have lower BSV scores compared to patients with anterior fractures [30].

It was hoped that enough orthoptic follow up data for the conservative management group are available. Most of the conservatively managed patients had only single orthoptic visit. Measurement of diplopia score improvement (BSV) for this group would have provided us with quantitative measurement to compare the managements' results. This in turn will help to resolve some of management controversy.

This study demonstrates a numerical presentation of diplopia and ocular motility for blow out fractures of the orbit, in surgical and conservative management groups, It is hoped that use of BSV scores for diplopia would be encouraged in future studies allowing comparison of results, and might further bring agreement regarding the management protocol of blow out fracture injury.

Conclusions

Binocular single vision (BSV) has more influence than uniocular fields of fixation (UFOF) on diplopia outcome in term of improvement and follow up time.

Timing for surgical intervention and the choice of implant material have no influence over diplopia surgical outcome.

On the basis of this study, surgical intervention would not be recommended for blow out fracture cases with BSV score >80% for correction of diplopia alone.

Final summary and management suggestions

The main focus of this study series was to investigate the possible factors might influence ocular motility and diplopia outcome. In relation to enophthalmos, it has been felt that there has been, over the last decade, general agreement about the relation of orbital size changes and resultant enophthalmos. In addition, diplopia which is the most important complication of orbital blow-out fracture (Orgel, 1971) appears to be the main driving factor for management dilemma.

It seems that direct muscle injury as a result of this type of trauma did not enough attention in terms of surgical decision. The primary aim of surgical repair for blow out fracture is to minimise orbital soft tissue damage and to restore a full field of functional binocular single vision (Carroll and Ng, 2010). This is usually achieved through releasing of the herniated or entrapped orbital tissue in the fracture defect. However, tissue involvement in orbital blow out fracture, for which surgery aim to rectify, is not the only influential factor on ocular motility. Damage to the fibro-fatty-muscular complex should be considered in this type of injury (Iliff et al., 1999; Koornneef, 1982; Manson, 2007). Therefore, the outcome of surgery might be unpredictable, as the extent of orbital tissue damage and it contribution to ocular motility deficit may not be readily determined at the time of injury.

The controversy regarding surgical intervention versus conservative management may not reflect only the inability to predict, on clinical basis, who would recover from the ocular motility disturbances (Gosse et al., 2009), but may be related, as our data showed, to the limited role of surgery in terms of timing, approach and the type of implant material in improving the ocular motility outcome.

Evidently surgery does not provide the ideal solution for all ocular motility problems in this type of trauma. About 80% of our cases presented with variable degrees of diplopia postoperatively. Furthermore, cases with low preoperative diplopia scores which showed better improvement in comparison with higher BSV scores, which might justify surgical intervention, were under the risk of unfavourable outcome. Moreover, cases with orbital muscle herniation which represent a positive indication criterion for surgery, also, were under the risk of unfavourable outcome.

Koornneef (1982) believed that repair of a pure blowout fracture by placement of an implant may not address the real cause of the diplopia, which is disruption of the ligament system and septa. This could be the reason behind the fact that diplopia is unlikely to be completely corrected by surgery (Jones, 1994; Kugelberg et al., 1998; Stassen and Kerawala, 2007), which concurs with our findings.

Although making prediction for the need of surgery in blow out fracture is difficult (Mathog, 2000), it is logical to assume that effective approach for management of diplopia in this type of injury should consider more than one factor. These factors are: preoperative BSV score; and the level of tissue herniation.

Our data showed that BSV score has an important prognostic value in term of postoperative diplopia score, follow up time, number of post operative visits and subjective diplopia outcome. It also showed that patients with BSV >80% score do not benefit from surgery, while patients with BSV <60% benefit from surgery more than other BSV categories in terms of BSV scores.

However, BSV score could not be used alone as surgical management guide criterion. Surgery aims to restore single vision through restoring the normal position of the herniated or entrapped orbital tissue, as such, it worth considering the influence of tissue involvement on binocular vision. It appears from our data, that orbital fat herniation which forms about half of the cases with surgical intervention has no significant influence over "no tissue herniation" in relation to diplopia and ocular motility. It is logical to consider this finding in surgical intervention.

Because of lack of adequate follow up data, from the conservative patients' group it would be difficult to suggest definitive guide for the management of blow out fractures of the orbit. It is possible, however, it suggest a management guide through the triangulation of both studies findings: Surgical intervention might be considered for cases with BSV scores≤60% with for cases with orbital muscle entrapment/herniation. Conservative management might be considered for cases with BSV ≥80% with no tissue or orbital tissue herniation.

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b) Developing outcome measure

Identifying putative items for orbital fracture outcome measure

Introduction

Despite the fact that many quality of life measures have been developed, literature review revealed lack of validated orbital or, even, facial trauma specific QOL questionnaire.

Researchers investigated the influence of facial trauma on QOL using several HRQOL instrument. Among measures used to assess facial trauma influence; Eysenck personality questionnaire [1]; hospital anxiety and depression scale, Beck depression inventory, general health questionnaire, and; SF-36, depression, and trauma scales [2]; the Hospital Anxiety Depression scale, a modified University of Washington Quality of Life questionnaire and five non-validated facial trauma items [3]; The Posttraumatic Disorder Scale, The Social Readjustment Rating Scale [4]; Acute Stress Disorder Scale, Satisfaction With Appearance Scale COPE Short Form, Impact Message Inventory, Participatory Style of Physician Scale, Injury Severity Scale [5]; World Health Organization QL Questionnaire (WHO QoL-Bref),the Hospital Anxiety and Depression Scale [6].

Lack of orbital trauma questionnaire mandates development of quality health instrument for orbital trauma cases, as different health conditions have different impact on physical and psychological aspects of patients' lives [7]. To the best of our knowledge, article published by Folkestad et al [8] is the only article in this field. Their study tried to find the level of agreement between patients and physicians about the subjective outcome in orbital floor fractures.

Materials and methods

A hybrid model for HRQOL measure has been adopted in this study [7] through item addition from the qualitative study data to a HRQOL measure (Amblyopia and Strabismus Questionnaire) which has face validity through its fair coverage to the most important symptoms of orbital blow out fracture: diplopia and enophthalmos. It also has the participation restriction elements related to the impairment caused by diplopia and eye appearance.

Amblyopia and Strabismus Questionnaire (A&SQ) (Appendix 2) has been tested for validity and item coverage using data extracted from 21 semi-structured interviews with orbital blow out fractures' patients. The new suggested instrument was developed through A&SQ modification via item addition. This questionnaire development model based on [9].

Results

Table 15 shows the items and domains of Amblyopia and Strabismus Questionnaire [10] in relation to what have mentioned by interviewed patients (study B).

In front of each item, patient quote were documented. Diplopia domain shows high content coverage compared to other domains. There are domains related to other amblyopia and strabismus symptoms such as visual disorientation and distance estimation. Although these symptoms are not usual blow out fracture's findings, there were patients' complaints mentioned in the interviews related to 2 items for each of these domains.

Table 16 shows that all the items of "eye appearance" domain and all but one item from the "distance estimation" domain are unsupported by the data extracted from the qualitative interviews.

Table 17 shows the suggested items to be included in the modified A&SQ. six items to be added in diplopia domain and three items to be added in appearance with social contact domains. In addition, a new domain "pain and sensory disturbances" has been suggested.

In front each item the number of responses reported to show the relative importance of each of these items in patients' experience [7]. The pain and sensory disturbance domain's items include trauma pain and sensory disturbances related to infra-orbital nerve injury, which have adopted from [8].

Accordingly, items and domains for the suggested blow out trauma questionnaire will be as shown in Table 18. The green cells refer to the added items and domains. The yellow cells refer to the items which were presented in both original A&SQ and the qualitative data.

Table 19 demonstrates the final format for the suggested instrument. Three items have been added to diplopia domain, two items were added to appearance domain and one item was added to "seeing with two eyes" domain.

Table 15 A&SQ interview data supported domains and items with related patients' quotes.

Domain	Item number	Summary of item	Qualitative	Representative quotation from data
Seeing with two eyes	1	Ability to see with both eyes	4	"I couldn't read. Even my glasses I couldn't see the chair"
Distance estimation	9	Picking items	6	"I'm straining all the time and, you know, like doing the smallest things like. I mean even picking a book up or a magazine, I can't because it's hard work, you know."
	12	difficulty walking down stairs	5	"going downstairs and things is quite difficult" "If I'm walking down flights of stairs, I can't see the edges of the steps"

	13	Playing football (sport)	11	“Playing sport would just be a nightmare”
Visual	14	difficulty in finding the way	5	“because of the double vision I get very disorientated and fall
	15	Difficulty in finding the way in supermarket	2	“A little bit more sort of anxious on stairways in say shops or escalators, that sort of thing. I want to hold on more”
diplopia	17	I see double	2	“I’d got a lot of double vision. I’d got one image above the other one”
	18	Double vision disturbed daily activities	6	“I just cut a lot of things out”
	19	Being careful	2	“A little bit more sort of anxious on stairways in say shops or escalators, that sort of thing. I want to hold on more”
	20	Effect on daily activities	7	“I didn’t really do anything. I was just at home just sitting down, lying in bed and doing nothing”

Table 16 A&SQ domains and items unsupported by interviews’ data

Domain	Item number	Item summery
Seeing with two eyes	2	Fear from losing vision in the other eye
	3	Fear from problems in the other eye
Distance estimation	4	Ability to estimate distance
	5	Can see in depth well.
	6	uncertain when putting something on the table
	7	miss my hold when shaking hands
	8	car parking
	10	it difficult to put a plug in a socket
	11	have problems pouring out drinks
Visual disorientation	16	difficulty finding my way in a railway station
diplopia	21	have to squint with one eye in strong sunlight
Appearance of my eye	22	difficulty making eye contact in a one-to-one conversation
	23	difficulty making eye contact with people in a group conversation
	24	I have a squint

	25	Because of my squint I feel uncertain
	26	If I did not have a squint, I would be more self-confident

Table 17 pain and facial sensory disturbance domain, diplopia and eye appearance items to be suggested for modified A&SQ

Domain	Suggested item	Frequency of response
diplopia	Ability to do the job	17
	Ability for driving	9
	The need for extra effort to do things because of double vision	2
Appearance and social activities	Facial asymmetry	5
	Embarrassment from facial appearance limited my social activities	10
Sensory disturbance (suggested domain)	Pain	13
	Pain while moving the eye	3
	numbness	5
	Tingling sensation	2
	others	4

Table 18 suggested blow out fractures' questionnaire domains and items with A&SQ and qualitative data inclusion for each item

Item no.	Item summery	A&SQ inclusion	Qualitative data inclusion
	Seeing with two eyes		
1	I can see equally well with two eyes	x	x
2	I am afraid of losing my injured eye		x
3	I am afraid of losing my better eye	x	
4	I am afraid that something might get into the better eye	x	
	Distance estimation		
5	I can estimate distance well	x	
6	I can see in depth well	x	
7	I am uncertain when putting something on the table	x	
8	I miss my hold when shaking hands	x	
9	I have difficulty with parking my car	x	
10	I find it difficult to cap a pen or a felt-pen	x	
11	I find it difficult to put a plug in a socket	x	
12	I have problems pouring out drinks	x	
13	I have difficulty walking down stairs	x	x
14	I have problems playing ball games	x	x
	Visual orientation		

15	I have difficulty finding my way in a mall	x	
16	I have difficulty finding my way in a department store or a large supermarket	x	
17	I have difficulty finding my way in a railway station	x	
	diplopia		
18	I see double	x	x
19	Double vision disturbs me in my daily activities	x	x
20	Because of double vision, I am unable to do my job		x
21	Because of double vision, I am unable to drive		x
22	When I am tired, I must be very careful not to miss my hold	x	x
23	I have to move more slowly when I am tired, because of my eyesight	x	x
24	because of double vision I need for extra effort to do things		x
25	I have to squint with one eye in strong sunlight	x	
	The appearance of my eye		
26	Both sides of my face are not symmetrical		x
27	Because of my facial appearance I feel embarrassed		x
28	I have difficulty making eye contact in a one-to-one conversation	x	
29	I have difficulty making eye contact with people in a group conversation	x	
30	I have a squint	x	
31	Because of my squint I feel uncertain	x	

32	If I did not have a squint, I would be more self-confident	x	
Pain and sensory disturbances			
33	Pain		x
34	Pain while moving the eye		x
35	numbness		x
36	Tingling sensation		x
37	others		x

Table 19 the suggested format for Orbital Trauma (modified A&SQ) Questionnaire

Item no.	Included items	All of the time	Most of the time	Some of the time	Little of the time	None of the time	Not relevant
			Seeing with two eyes				
1	I can see equally well with two eyes	Yes	No	If yes skip to question 5			
2	I am afraid of losing my injured eye						
3	I am afraid of losing my better eye						
4	I am afraid that something might get into the better eye						
			Distance estimation				
5	I can estimate distance well						
6	I can see in depth well						
7	I am uncertain when putting something on the table						
8	I miss my hold when shaking hands						
9	I have difficulty with parking my car						
10	I find it difficult to cap a pen or a felt-pen						
11	I find it difficult to put a plug in a socket						
12	I have problems pouring out						

	drinks						
13	I have difficulty walking down stairs						
14	I have problems playing ball games						
Visual orientation							
15	I have difficulty finding my way in a mall, especially when I am there for the first time						
16	I have difficulty finding my way in a department store or a large supermarket, especially when I am there for the first time.						
17	I have difficulty finding my way in a railway station, especially when I am there for the first time.						

Item no.	Included items	All of the time	Most of the time	Some of the time	Little of the time	None of the time	Not relevant
	diplopia						
18	I see double						
19	Double vision disturbs me in my daily activities						
20	Because of my double vision I am unable to work						
21	Because of my double vision I am unable to drive						
22	When I am tired, I must be very careful not to miss my hold						
23	I have to move more slowly when I am tired, because of my eyesight						
24	because of double vision I need for extra effort to do things						
25	I have to squint with one eye in strong sunlight, for instance at the beach						
	The appearance of my eyes						
26	Both sides of my face are symmetrical	Yes	No	If yes skip to question 33			
27	Because of my facial appearance I feel embarrassed						
28	I have difficulty making eye contact in a one-to-one conversation						

29	I have difficulty making eye contact with people in a group conversation						
30	I have a squint						
31	Because of my squint I feel uncertain						
32	If I did not have a squint, I would be more self-confident						
Pain and altered facial sensation							
33	How often does pain interfere with your daily activities						
34	How often unusual sensations (numbness, tingling or other sensations) interfere with your daily activities						

Discussion

Effects of health care should not be directed towards clinical measures target the frequency and severity of diseases alone. It must include the patients' well-being [11]. In other words, the aim of medical intervention is to help clinician to make patients feel better [12]. However, it seems unclear how can this fact be implemented in devising HRQOL instrument in terms of what are the important items to be included. There are two aspects of importance; the patient's and the clinician's aspects.

From the clinician's point of view, clinical experiences (experts' opinion), is one of the main item selection sources for questionnaire development [13, 14]. Juniper et al [15], in the item reduction phase for development of Asthma Control Questionnaire, relied on 100 asthma clinicians. The item importance decided upon the frequency of response they had from these clinicians about each of 10 asthma control symptoms.

The level of item importance is considered according to the its influence on the medical intervention as: Crucial measure, without which the physician cannot make rational decision without information how it affects the QOL; Important which is the QOL information that provide aid to optimal treatment decision; Secondary which is the information might be of relevance but it is not likely to influence the treatment decision; or Irrelevant [16].

Accordingly, the inclusion of patients' concerns and how they perceive their health condition might not be of use in the medical decision process. It will not bring an added clinical value to the intended HRQOL instrument to be devised. This fact might limit the value of quality of life measurement from the patient's perspective.

"I didn't see why … why [expressing my concerns] would it help [the surgeon] do his job any better? Because, at the end of the day he still has to treat it in the same fashion no matter what the circumstances." (Case 15)

The previous quote clearly demonstrates the gap between clinical and patient's sides of relevance. This might be the reason behind the argument that quality of life measures are biased by clinical rather than patient's judgement [17-19].

This is one of the issues could face a researcher as s/he tries to use qualitative interviews' data in developing or modifying a quality of life instrument. Qualitative data is about patient experience and perception, whereas item inclusion in many quality of life instruments is mainly about physical functioning [20, 21]. It might be argued that patients concerns are related to the physical abilities inflicted by any health problem. In fact qualitative data has shown the contrary. Because of lack of biomedical knowledge, patients tend to have unrealistic concerns about their conditions and sometimes unrealistic expectations about the treatment outcome.

Item selection

Guyatt *et al* [7] suggested certain steps for new instrument development following one of two models; Rolls Royse Model and Volkswagen Model. These steps are item selection, reduction of number of items and presenting.

The Rolls-Royce model requires detailed semi-structured interviews with 50 -100 patients to determine all areas of dysfunction and patients' concerns for item selection. A step which usually bypassed by Volkswagen model which requires reviewing 2 existing instrument, consulting content area experts to choose appropriate item. Accordingly, Volkswagen model bypasses the first step of item selection.

The method followed in the identification of suitable items in the newly suggested orbital questionnaire measure (M A&SQ) represents a combination between two models (Rolls Royce and Volkswagen model). It utilises tested and validated A&SQ [10, 22, 23]. And qualitative data for 21 interviewed blow out fracture patients.

Devising a modified measure based on other instrument has several advantages; time saving; the items of the original instrument have been tested and validated; and there are limited ways to ask about certain questions in relation to the relevant dimensions or problems shared by the original and newly devised instruments [14].

Regardless the method or model used, the developed QOL instrument should fulfil certain criteria to achieve the aims for which the instrument has been devised for. These criteria include coverage, validity, reliability, responsiveness and sensitivity. Coverage means that each symptom, condition or social role which is important to the patient should be covered by the instrument. Validity simply refers to the fact that the instrument targets the health condition it claims to measure. Reliability of an instrument means its consistency within similar conditions. The instrument considered to be responsive when it reflects changes in patient condition with treatment or intervention. Sensitivity is the ability of the instrument to detect sensitive changes in quality of life [24].

The reason for choosing A&SQ among other eye disease specific questionnaires such as National Eye Institute Visual Functioning Questionnaire - 25 (VFQ-25) [25], VF-14 [26] is the relative face validity and item coverage in relation to orbital trauma, in the aspects of diplopia and aesthetic concerns. Face validity simply is the impression that the instrument is assessing the desired qualities, whereas content validity relies on the judgment that the instrument contains all the relevant items or domains [14].

A&SQ consists from five domains with 26 items. The five domains are: fear of losing the better eye, distance estimation, visual disorientation, diplopia and problems with social contact and cosmetic problems. Most of the answers follow the same 5-points ordinal scale used in VFQ-25: none of the time = 1, a little of the time = 2, some of the time = 3, most of the time = 4, and all of the time = 5 [10].

The “seeing with both eyes equally” domain shows the psychological influence on patients with amblyopia and strabismus. Other domains show the impairment and related activity limitations. Participation restrictions have been covered by “eye appearance domain”. The phrasing used in this domain’s items was not similar to blow out fractures’ patients. This might explain why this domain is not supported in the interview data, despite the psychosocial concerns reported by the interview data (Table 16).

Beauchamp *et al* [27] used six items strabismus disability questionnaire (Appendix 3). This instrument despite its content validity over A&SQ for orbital trauma patients and being short, which decreases the burden on the patients, has two downsides: the first one is that the response rating range from 0 to 10 (none=0 to severe=10), and there is a good evidence from the literature suggests that people are unable to discriminate effectively beyond seven rating levels [14]; the other downside is that each item by itself represent a group of items; for example “concerns” item:

“Concerns/doubts about the future—including worry about possible blindness, inability to work, read, etc”

Short instrument might be under the risk having low reliability coefficient (which ranges from 0-1) and higher measurement error [14]. This will not only negatively influence the instrument reliability, but it will lose the specific influence of each of these included items from the response.

Folkestad et al.[8] studied patient and physician agreement over orbital fractures symptoms’ improvement after surgery, including orbito-zygomatic fracture dimensions: eye sight, physical appearance, sensitivity and mouth opening and bite. They used VAS with anchors “never” “always” at the extreme with “sometimes” and “often” in between.

Eye sight dimension includes double vision; physical appearance includes sunken eye, visible scar, and flattened cheek; sensitivity dimension includes numbness, pricking, and pain; lastly is the mouth opening and bite dimension, which includes reduced mouth opening and affected bite items. they added the choice of “other” for each dimension [8].

The problem with Folkestad et al. [8] instrument, despite its simplicity is including only one scale for each attribute. For example; diplopia has been considered as one item, whereas it is better to be considered as a dimension with multiple items. For cases with blow out fractures of the orbit in which postoperative diplopia as a common problem, such scale will cost the clinician important information about the wide influence of diplopia on patients' QOL, as the qualitative data has shown. In addition to reliability problem yielded with such short instrument compared to longer QOL instrument [14].

A&SQ, on the other hand, does not have the quite required content validity in relation to orbital trauma patients' problems, as qualitative data has shown. Ten out of 26 items have been supported by qualitative data Table 15 and Table 16.This mandates certain modification to improve content validity and coverage of this instrument. Modification includes items' addition in diplopia and eye appearance domains, which have been supported by interview data (Table 17).

The item addition criteria in the suggested HRQOL measure are guided by literature review and the item importance. One of the importance criteria is the frequency of reports "item frequency" [15] in addition to the potential responsiveness the item yields [7]. Although qualitative data is not about frequency or recurrence of findings, the frequency of reports in the qualitative data reflects the relative item importance (Table 17). Increasing number of items might increase the questionnaire burden on participants. However, it positively affect the instrument reliability [14].

Diplopia domain

As it may be seen in A&SQ (appendix 2), item 18 in diplopia domain shows the influence of diplopia on life activities in general without separation between the influence on household activities, work and driving:

"Double vision disturbs me in my daily activities (household, study, school, hobby, work)".

Qualitative data shows that patients usually separate their expressed concerns about their work, driving and other daily (household) activities. In addition, some of their daily life activities such as shopping, watching TV and reading do not to appear as frequent as work wise or driving wise concerns.

"Obviously I can't work, can't drive." (Case 11)

Furthermore, some of quality of life measures, like Sickness Impact Profile [28] and WHO quality of life (BREF) [29] do separate the daily work from household activities' item. The job wise influence on patients with diplopia in term of activity limitations has been acknowledged by [27] in their 6 item strabismus disability questionnaire.

"Difficulty with non-work-related tasks of daily living—including walking, driving, reading, sports, etc" (daily task item)

Moreover, diplopia seems to have variable degree of severity during the daytime.

"It's usually worse in the morning. I: Worse in the morning? IV: Yeah, it's always worse in the morning. I: And then? IV: And when I'm tired at night it seems to get worse again. So in

the middle of the day it's not as bad."(Case 20)

This might influence some activities over others and the possibility to cope with its severity while performing certain tasks. Consequently, the diplopia influence on work and driving has been included in 2 additional items within diplopia domain.

Eye appearance and social influence domain

Despite the face validity of eye appearance and its social influence domain, it does not show the content validity according to what the interviews have shown. There have been appearance concerns with associated social contact problems in more than one level, which required being included within eye appearance and social contacts domain.

It should be considered that eye appearance and related social effect is not only related to enophthalmos, but is it related also to participation restriction influenced by circumorbital ecchymosis haemorrhage and facial scaring which have been reported by orbital blow out participants.

"..... When I had the black eye, I had a really bad black eye and my face was swollen and my cheek. And when I walked around and people would look at us it didn't make us feel very good. I was in the supermarket with my mum and I was getting quite a few dirty looks off people because they obviously thought I'd been fighting, sort of a thug, and that wasn't the case. So it wasn't nice to walk round and having the feeling that people might just be judging you on how you look. (Case 13)

"It still knocks me confidence. Because every time I look in the mirror that's all I see. I just see a big scar going across me cheek. .... it's just the whole thing really, it just annoys us the way it is. That obviously it's not how it was. It's got a scar and it's dropped down. Obviously nobody's going to be happy if somebody's got a scar on their face." (Case 17)

It is early in this development stage to reduce unsupported A&SQ items. The fact that there are no supporting quotes from the qualitative data does not mean that these items are redundant. In addition removing these item without testing might result in missing effect for items are not included [21]. However, absence of signal effect of unsupported items upon testing might justify their reduction.

According to the grading criteria of A&SQ, questions 8, 13, 14, 15, 16, 18 and 26 have "not relevant" response for which the item does not apply to the participant condition. This response has been maintained and applied for all items in the suggested orbital trauma questionnaire to test the redundancy as suggested according to qualitative data interviews.

Pain and sensory disturbance domain

A&SQ lack the pain and sensory disturbance dimension. The justification for this domain addition is literature review, which shows the frequency of this item reporting in patients with orbital fractures which ranges from 24% to 84% [30, 31]; this item has been considered as an indication for surgical intervention in some blow out fractures' cases [32, 33].

This domain items were adopted from Folkestad *et al* [8] with wording modification for one item (prickling sensation) has been substituted by (tingling sensation) to match patients' phrasing.

“I’m getting a lot of nerve tingling” (Case 2)

“The tingly nose” (case 9)

The item (others) has been maintained as in Folkestad *et al* [8], in the suggested items as there are other sensory disturbances mentioned by patients:

“It feels like cold water running down my face, but they were cold on the inside” (case 2)

“It feels … that post-dentist feeling when your teeth feel almost too tight” (case 5)

“Inside of my mouth was hurting quite bad so I thought like there might be some problems with me like teeth being knocked out of place or something like that.” (Case 8)

Only one item has been added to the pain domain which was not originally considered by Folkestad *et al* [8], which is “pain while moving the eye", which has been raised by 3 participants.

Development of orbital trauma questionnaire based on qualitative data extracted from interviews with blow out fractures patients might raise the issue of item coverage, as blow out fracture is just one type of orbital trauma. However, blow out fractures have high incidence of diplopia compared with other orbital trauma cases [34-36]. Many studies have shown the wide influence of diplopia on patients’ QOL [37, 38]. Accordingly, extracting data from patients with other types of orbital trauma might not provide enough data about the influence of diplopia on patients’ experience.

The newly suggested instrument needs to be tested for item redundancy, reliability and responsiveness in orbital trauma cases. There is one limitation in the suggested instrument. It does not cover the psychological influence of the trauma itself. This is a problem of disease specific measures. This might limit this instrument value in measuring the influence of treatment on patient response to the trauma.

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