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THE RATIONALE BEHIND THE WIDE USE OF CALVARIAL BONE AND TITANIUM MESH IN ORBITAL FLOOR RECONSTRUCTION: A COMPARATIVE STUDY

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ABSTRACT

Aim: The purpose of this study is to compare the success rate and possible complications when using calvarial bone and titanium mesh as a reconstruction material for orbital floor; assessing their reliability in that field.

Methods: 17 patients with impure orbital blowout fractures were classified into 2 groups; in group A; the orbital floor was reconstructed using autogenous calvarial bone graft, while in group B; titanium mesh was the material used in orbital floor reconstruction. The degree of success, persistence of symptoms and possible postoperative complications in term of diplopia, enophthalmos, ocular motility were recorded and compared in both groups.

Results: 14 of the 17 patients were males and 3 females. Road traffic accident was the most common cause of trauma. Both calvarial bone graft and titanium mesh succeeded in orbit floor reconstruction effectively in terms of function and esthetics with minor amount of complications; one patient in the calvarial bone graft group experienced wound dehiscence, another patient of the titanium mesh group acquired enophthalmos post operatively, also there was a patient from each group who experienced ectropion. All patients with other symptoms as diplopia, ocular motility disorders and numbness were improved.

Conclusion: Calvarial bone and titanium mesh are a very good orbital reconstruction material with good functional and esthetic outcomes and low rate of complications.

KEY WORDS*:* Orbital floor trauma, calvarial bone graft, Titanium mesh, Reconstruction material.

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INTRODUCTION

The orbit is highly susceptible to injury because of its very complex anatomical structure with soft and hard tissues, orbital fractures are challenging to manage [(1)].

Fractures of the Orbital wall can cause immediate and long-term effects on both ocular function and facial aesthetics[(2)], it can cause diplopia, enophthalmos, extraocular muscle dysfunction and infraorbital nerve anaesthesia [(3)].

The indications for surgical reconstruction of orbital floor fractures, as well as the surgical means and used materials, are still issues of great clinical controversy. However, it is generally accepted that urgent surgical intervention is required in cases of trapped extraocular muscles causing a life-threatening oculocardiac reflex [(4)], and in large defect sizes over 50% of the orbital floor in order to restore the anatomical structure of the orbit and so improve the visual function together with the orbital appearance [(5)].

Regardless the continuous debate concerning which material is the ideal, orbital floor reconstruction can be done via autografts, allograft and alloplastic materials, surgeons use materials they believe will offer the best results with the lowest rate of complications considering the advantages and disadvantages of each material. Autogenous bone grafts were the first major class of materials used in orbital floor reconstruction, commonly used autologous grafts include the calvarium, rib, iliac crest, mandibular and maxillary bone [(2)].

Marchac[(6)] and Tessier[(7)] were pioneer in introducing the use of calvarial bone grafts (both full and split thickness) in orbit floor reconstruction, calvarium has the advantage of being in close proximity to the operating field facilitating its harvest, also it is radiopaque and the bone has good strength with intrinsic shape similar to that of the orbital floor, many studies showed that repair of orbital fractures with calvarium is safe and has a very good results in reduction of diplopia and enophthalmos[(2)] ,on the other hand, some surgeons do not prefer the calviruim; certainly due to donor site morbidity[(8)], also the use of calviruim has a variable degree of resorption together with its lack of pliability which lead to less precise recovery of orbital volume and less accurate reconstruction of the intrinsic orbital shape [(9)].

In 2003, Ellis [(10)] and Tan[(11)] were the first to show that titanium meshes are more accurate in orbital reconstruction in comparison to other bone grafts [(10)]. Other retrospective studies also supported these conclusions [(12)].

Titanium mesh can easily simulate the orbital bone structure due to its high malleability and its great tensile strength, also titanium is easily visualized on postoperative CT and is considered as an excellent choice for orbital fracture reconstruction [(13)]. However, on the other side, it was reported that titanium meshes may cause inflammatory reactions and other post-operative complications, such as infections, extrusion and diplopia [(14)].

The aim of this study is to compare the use of two major implants that are commonly used in orbit floor reconstruction: the calvarial bone and the titanium mesh, regarding their post-operative outcome and complications.

PATIENTS AND METHODS

Study Design

This study was conducted from October 2020 to August 2022 in Oral and Maxillofacial surgery department, Faculty of Dentistry, Cairo University including 17 patients (14 males, 3 females) diagnosed with unilateral orbital blowout fractures, the mean age was 37 years. Patients were classified into 2 groups according to the material used in orbit floor reconstruction: Group A included 9 patients; 7 males and 2 females, the outer table of cranial bone was used in orbital floor reconstruction, patients of this group had associated fractures necessitates the use of coronal flap to expose these fractures. Group B included 8 patients; 7 males and 1 female, 0.3 mm thickness titanium mesh was used for orbital floor reconstruction in this group. All patients had midfacial fractures associated with the orbital rim (impure blowout fracture). Exclusion criteria were patients with bilateral orbital blowout fractures (for comparison of the injured side to the normal side), orbital blow in fractures in children and loss of vision in either affected or both eyes. The protocol was approved by the The Ethics Committee of the Faculty of Dentistry, Cairo University, a detailed informed written consent was obtained from all patients including all the details of surgery and the possible complications.

Preoperative Preparation

A detailed history and complete clinical examination for the head and neck including full ophthalmological evaluation together with preoperative facial computed tomography (CT) scan with axial, coronal and 3D view was performed routinely for all patients (***Figures 1a***). Indications for surgical intervention were found including presence of diplopia, entrapped muscles, enophthalmos and CT evidence indicating large orbital floor defect (more than half of the orbital floor). Patients were operated at least after 1 week from time of fracture to allow and observe for the spontaneous resolution of peri orbital oedema and the associated presenting symptoms.

Surgical Procedure

All surgeries in both groups were performed under general aesthesia using nasal intubation by the same surgeon and team. The surgical approach was subciliary in all the patients, soft tissue dissection was done up to the infraorbital rim, followed by opening the periosteum and subperiosteal dissection deep to orbital floor. In the orbit: a malleable retractor was used to elevate the orbital tissues improving visibility for the orbital fracture and defect and also to avoid penetration of the orbital tissues by reducing of the herniated orbital contents from side to side, this was followed by identification the stable defect borders that will support the used graft material regardless its type, careful attention was given in incisions to simulate the natural slopes and curve of the floor of the orbit (***Figures 1b***). After repositioning the orbital content, each orbital floor was reconstructed using either calvarial bone or titanium mesh according to the patient's group:

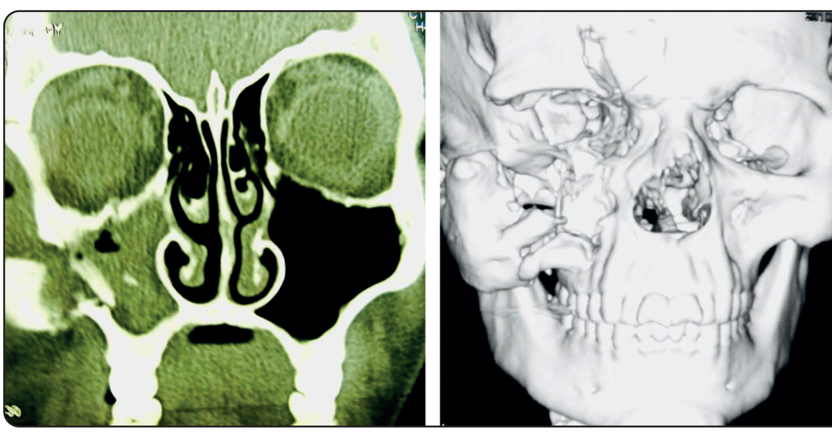

Fig. (1a): Preoperative 3D reconstruction and coronal CT scans

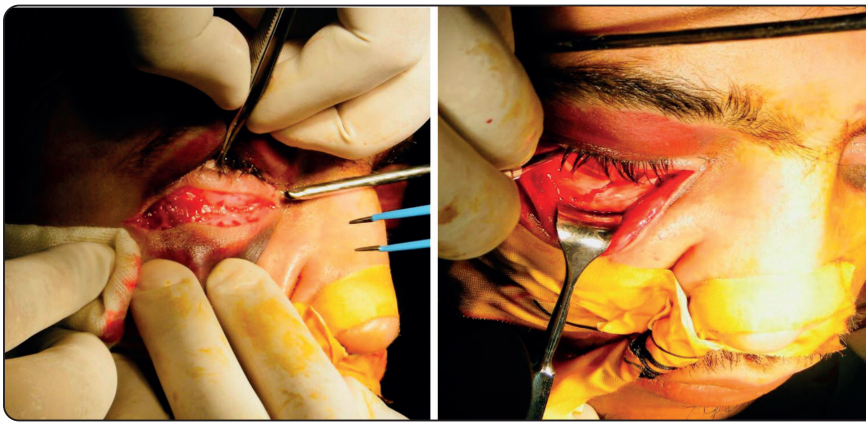

Fig. (1b): Subciliary incision used for accessing the orbital floor

Group A:

The previously shaved parietal calvarial region was disinfected. Coronal skin incision was performed through the layers of the scalp until the cranial bone was exposed, patients of this group had other fractures making this incision mandatory. Round bur was used to mark the required graft, undermining the bone with chisels was done until the outer table of the bone block was freed obtaining split thickness graft (***Figures 2a***). Saline was used to rinse the surgical field, closure was done by absorbable sutures, followed by closure of the skin of the scalp by cutaneous needles staples, the graft was shaped, contoured and stabilized at the orbital floor defect with 1.0 mm titanium screws.

Group B:

Titanium mesh 0.3 mm thickness was fixed with 1.0 mm titanium screw to reconstruct the orbital floor, titanium implants were cut and manipulated to fit the floor of the orbit with enough overlap over the fracture edges. The anterior aspect of the mesh was put comfortably outside the orbital rim while the posterior aspect resting on the orbital floor behind the most posterior aspect of the fracture site, by this way; the mesh which is seated across the fracture site with sufficient overlap on the nondisplaced bone does not need much fixation with screws, as the tamponade effect of orbit soft tissues will hold the mesh in place, also the scar capsule will stabilize the mesh in its place more (***Figures 2b***) .

In both groups, a Forced Duction test was performed to check for the normal globe movement prior to closure of surgical wound using 6-0 vicryl sutures, patients were discharged after one day from doing the surgery, keeping them on antibiotic clindamycin 3000 mg three times daily for five days (Clindam 300 mg capsules, Sigma pharmaceutical industries, Egypt) and non-steroidal anti-inflammatory analgesic diclofenac potassium 75 mg two times daily for five days (Cataflam 75 mg IM injection, Novartis Pharma AG, Cairo, Egypt.)

Follow-up

An appointment was given after 1 week from the operation for suture removal, also for assessment both clinically and radiographically via postoperative CT, this was followed by follow-up recall after 1 month, 3 months, 6 months and 9 months post-operative; patients were assessed postoperatively for diplopia, enophthalmos, ocular motility, their satisfaction for the scars and any other finding along the follow-up period.

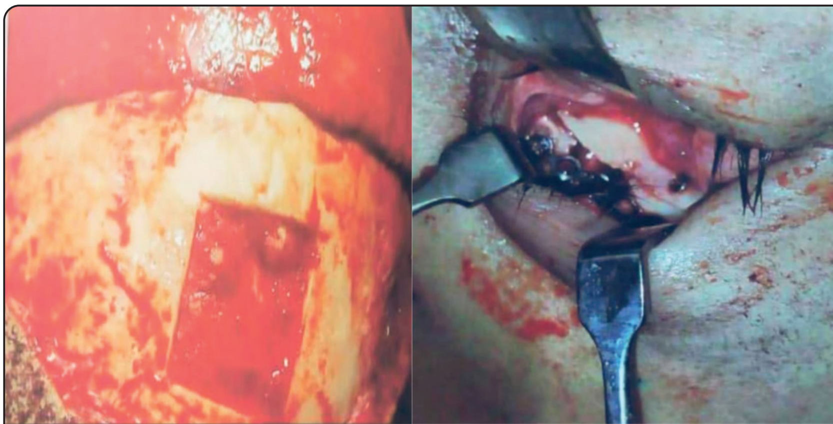

Fig (2a): Harvesting the calvarial bone and reconstruction of the orbital floor using the harvested graft in patient from group A

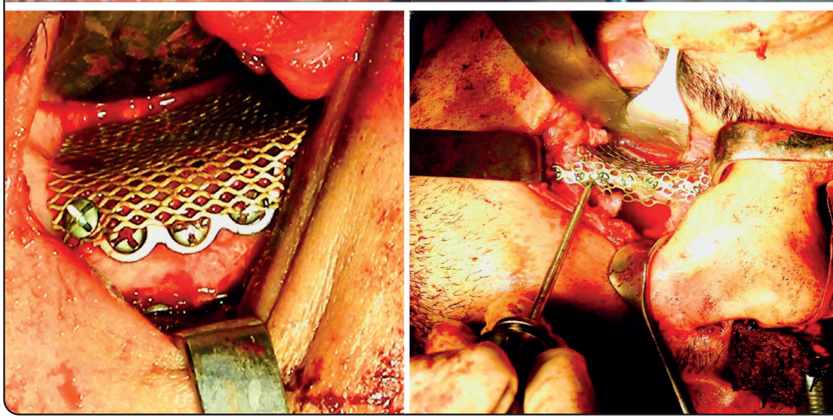

Fig (2b): Reconstruction of the orbital floor using titanium mesh in patient from group B

RESULTS

Our study population included 17 patients suffering from impure blow out fractures,14 patients (82.3%) were male, and 3 female patient (17.64%). The age ranged from 19 to 56 years (with mean age 37 years). Road traffic accident was the most common cause (11 cases -64.7%), followed by interpersonal violence (4 cases-23.52%) as the second cause followed by industrial accidents (2 cases-11.77%). All patients suffered preoperatively from diplopia, enophthalmos and step deformity at the floor of the orbit, 11 patients had restricted eye movement. Patients of both groups were treated by ORIF (open reduction and internal fixation), the surgeries were done at least after 1 week from the injury giving the chance for the resolution of the oedema, access of the floor was done via subcilliary approach. Out of 17 patients, 9 patients were repaired by autogenous split calvarium bone graft (Group A) and 8 patients with titanium mesh (Group B).

After the operations, all the 17 patients were satisfied with their final results and function, all cases diagnosed by CT with large orbital floor defect completely improved by comparing preoperative and postoperative CT scans, CT scan revealed well-aligned bony continuity together with maintenance of the floor reconstruction and well-positioned grafts, absence of step deformity after correction in all cases was observed **(figure 3)**, absence paraesthesia was seen in all patients after 9 months, there was no diplopia or abnormality in ocular motility in any case of both groups, 2 cases (11.77%), 1 from each group suffered from complication of ectropion. 1 patient in the calvarial bone graft group developed wound dehiscence that was treated by prolonged use of antibiotics and local dressing and the condition improved. None of patients exhibited exposure or infection in the titanium mesh in titanium mesh group, preoperative enophthalmos improved immediately postoperatively and after

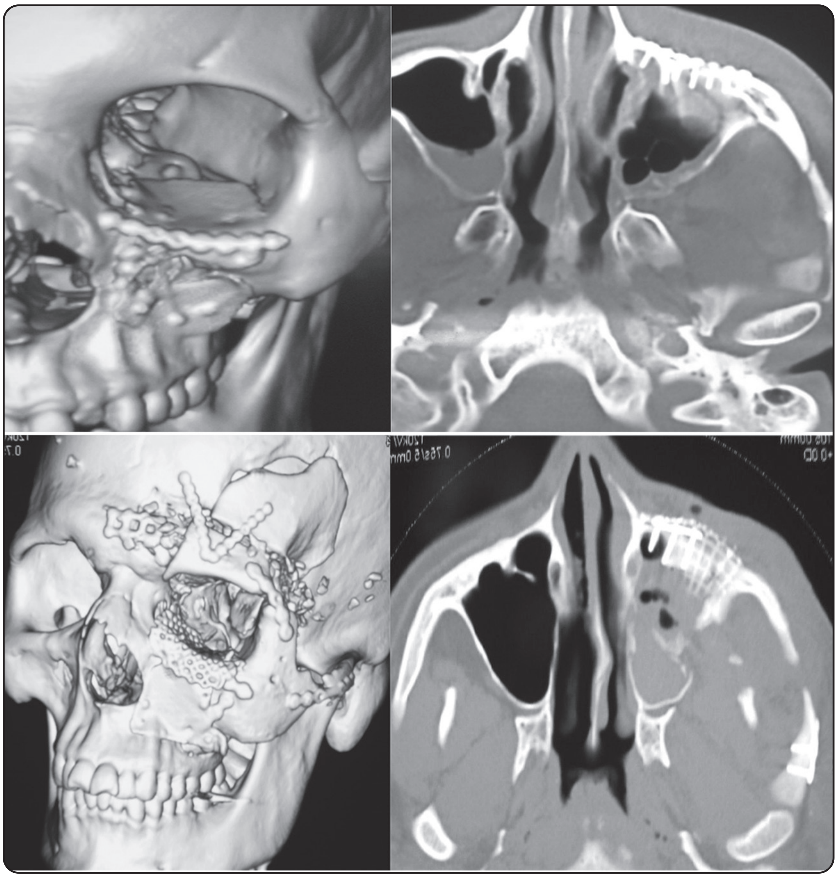

Fig. (3a): Patient from the calvarial bone graft group (group A)

Fig. (3b): Patient from group of the titanium mesh (group B)

Fig. (3) Showing postoperative CT scan with good floor reconstruction

4 months as observed by ophthalmological evaluation (by achieving clinically visible symmetric eyeball projection after surgery) in all cases, only one patient in the titanium mesh group developed late enophthalmos after three months, CT of this case showed atrophy of the retrobulbar fat with good position of the graft covering the whole defect, second revision surgery was done for this patient with placement of autogenous anterior iliac bone graft and the condition showed great improvement.

In general, no significant differences were found among the two groups of patients for all the analysed clinical parameters except for the surgery time which was expanded in the calvarial bone graft group due to the consumed time required for graft harvesting.

DISCUSSION

In our study, the diagnosis and treatment plan were gained by Computer tomography (CT) scans together with clinical history. There is an international agreement that the CT is considered the gold standard and the most reliable imaging technique in orbit fracture diagnosis [15].

Various approaches for accessing the orbital floor have been used such as transconjunctival, subciliary and infraorbital incisions [16]. Some authors prefer the use of more aesthetic trans- conjunctival approach; however, it has a risk of entropion occurrence and usually needs extra lateral canthotomy specially in huge fractures [17]. Unlike the transconjunctival incision, the Infraorbital incision leave visible scarring despite of offering direct orbital floor access [18]. In this study, we accessed the orbital floor and rim using the subciliary incision, we found it offering a good access together with low rate of complications, this coincides with a lot of authors who considered it as the best approach when compared to others [17].

Since orbital floor reconstruction was first described in 1889 by Lang [10], it is usually a straightforward operation but with a lot of debate regarding the best material for reconstruction. Many autogenous and alloplastic materials were used with various success rate and complications. A systematic review evaluating the used materials for orbital floor reconstruction found that there is no conclusive evidence to name one material as "better" than another; rather, the surgeon must rely on his own experiences and the unique characteristics of each individual material in developing the best treatment plan [19].

Most surgeons considered autogenous bone graft as the ''gold standard'' material in bone tissue repair[20]. Regarding orbital floor reconstruction, there was a common belief that the split calvarial bone graft being cortical bones was the most appropriate implant graft in orbital reconstruction[21-22-23,], in our study we experienced very good results with minor complication rate in the calvarial bone group, also Shetty et al. [24] and Ram et al. [25] monitored patients using calvarial bone grafts in orbital reconstruction for a period of 1.5 years post-operatively, they observed excellent restoration of the orbital floor and extraocular movements in all cases; there were transient complications, such as diplopia and enophthalmos, this complication was deemed not to be related to the use of calvarial graft.

Our results agree with Ilankovan et al. [26] and Guo et al.[27] who claimed that the calvarial bone seems to be one of the best options in orbital reconstruction. The graft can be fixated by screws and/or plates, also it may be used in conjunction with an alloplastic material such as titanium mesh[28-29].

On the other hand, Siddique et al. [30] stated that, although the cortical calvarial bone has very good strength, but its use is associated with less favourable aspects; its harvest might be associated with some complications, it is difficult in manipulation with fracture risk due to the lack of flexibility limiting its ability to fit the orbital floor contour. Unlike what we experienced, Glassman et al. [31] and Philips et al. [32] experienced unpredictable resorption of the calvarial graft in their study and stated that it can vary over a quite wide range. This might be because we had fixated the graft rigidly to the surrounding tissues, as this can promote implant vascularization and new bone in-growth as mentioned by many authors [28-31].

Calvarial graft usually harvested via coronal approach, we experienced a significant increase in surgery time and patient time under general anaesthesia, in our study we restricted this type of graft to patients who already have other fractures that necessitates this surgical approach to be fixed, however if there were no other reasons to make a coronal approach, the surgeon should weigh the possible advantage of the added exposure via the coronal approach with the surgical trauma and added time induced with that approach.

The trend toward using alloplastic materials is likely due rapidly growing evidence showing their efficacy and safety combined with the ease of use and reduced time together with absence of donor site harvest. A survey was made in 2014, showed that porous polyethylene and titanium mesh were the two most commonly used materials in orbital floor reconstruction [33] but still with risk of infection and exposure [34].

In our operations, we used titanium mesh for reconstruction of the orbit floor and titanium plate in repairing fractures of the orbital margin, the used mesh was adequately seated across the fracture site with abundant overlap onto the non-displaced bone, this way proved that; it does not need much fixation and tamponade effect, also it offered long-term rigid support in reconstruction with no complications regarding infection, iatrogenic injury and displacement, we had only one case who acquired late enophthalmos with absence of evidence that the reconstruction material is the cause of developed enophthalmos.

CONCLUSION

The results of our study demonstrate the effectiveness of both the calvarial bone and titanium mesh in orbital floor reconstruction with high success rate and low rate of complications, with no significant differences between the two grafts regarding aesthetic and functional outcomes, making them one of the best options in orbital floor reconstruction.

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