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Reconstruction of Orbital Blow-Out Fracture by Titanium Mesh Versus Autogenous Bone

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ABSTRACT

Orbital trauma may cause significant facial deformities while also affecting eyesight and the nerve system of the face. Most orbital floor fractures are open defect injuries, which separates them from other face bone fractures **[10]**.

Forty percent of the craniofacial injuries are orbital fractures; the orbital floor, because it is the thinnest of the orbit's four walls, is the one that sustains injuries the most often. The relevant literature indicates that these fractures account for 67.84% of all instances of the bones around the eye. Generally, the fracture of these bones related to orbital floor may be divided into isolated and complex fractures; the first is isolated to bones around orbit, while other one is involving other around orbit bones a: cheek bones, forehead bones and naso-ethmoidal **[5]**.

Objective: Our goal of the research to assess whether titanium mesh implants or cranial bone grafts were more appropriate for internal orbital repair for clean rupture fractures.

Methods: The case series method was utilized in this prospective and retrospective analysis on patients who had internal orbital reconstruction using titanium mesh (0.4mm thickness) or a skull grafting (external table) at Sohag University Hospital and Luxor University Hospital for 2 years Study.

Included 40 men and women suffering from ex-plosive orbital fractures. Patients were divided into 20 patients who underwent surgery using titanium mesh (Group A) and 20 patients who underwent surgery using autologous bone graft (Group B).

Results: Relationship between before and after surgery with titanium mesh ophthalmic problems did not show a statistically significant phenomenon (blindness), and the data were statistically significant (double vision, motion restriction, suborbital hypoesthesia, vertical abnormality), but in case of relation between autogenous bone and titanium mesh ophthalmic problems in preoperative surgery do not show statistically significant values for all parameters.

Conclusions: Autologous bone grafts do not cause immunological problems, but the number of donor sites is limited. There may also be problems related to pain in the second site, mismatch of mechanical properties of the host bone, and tendency to resorption. Titanium mesh, a synthetic biomaterial, is an expensive but good alternative and can overcome these limitations.

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Key Words: *Orbital Blow out fracture – Titanium mesh – Autolgoua bone graft.*

Ethical Committee Approval: Study approved by the Ethical Committees of the Faculties of Medicine of Sohag and Luxor Universities.

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INTRODUCTION

Forty percent of the craniofacial injuries are orbital fractures; the orbital floor, because it is the thinnest of the orbit's four walls, is the one that sustains injuries the most often. The relevant literature indicates that these fractures account for 67.84% of all instances of orbital fractures. Generally, orbital floor fractures may be divided into pure and impure blowout fractures; the former are isolated orbital floor fractures, while the latter are also linked to an orbital rim fracture; however, involving other skeletal elements: Zygomatic, frontal, naso-ethmoidal, or maxillary bone **[1]**.

It is generally accepted that there are two principal causes of orbital disfigurements: First, the morphological changes posterior to the eyeball, which may include a dislocation of the inferior orbital floor or a transverse expansion of the orbit, which play a role in the defect; and second, when soft tissue inside the socket is involved, the entire socket can be influenced **[4]**.

13.3% of fractures of bones related to face are concerned to bony orbit, while 0-55 percentage of instances are fractures of medial orbital wall alone. To re-establish the ocular function and appearances as quickly as feasible after a complex orbital fracture, reconstruction is necessary. After a trauma fracture, successful reconstruction of orbital and periorbital areas depends on careful surgical planning, precise surgical dissection, and the appropriate choice of implant size, type, and design [3].

The restoration of the bony orbit is particularly challenging because to its complicated shape, and it may be time-consuming, challenging, and technique-dependent to modify titanium mesh plates depending on complex anatomic demands [5].

The mesh plate of pre-formed titanium was placed to stabilize the globe of the orbit since 1984, the Food and Drug Administration has authorized titanium mesh for use in maxillofacial-cranial surgery, and it is now widely accepted for usage, particularly in major abnormalities [12].

Reconstruction requires the following: (1) Freeing of the orbital muscle, (2) The fractured floor should be reduced, (3) Reduction of fundus defects, (4) Frontal infection's prevention, (5) Restoration of physiological function, (6) Raising the recessed cheekbones, and (7) Adjustment of volume mismatch between orbits [6].

Alloplasts has also been used in absorbent forms as biodegradable polymers or in non-absorbable forms such as titanium, silicone, hydroxyapatite and bioactive glass. All these materials have their advantages and disadvantages. Demineralized bone matrix (DBM), a form of allograft, possesses the properties of osteoinductivity and osteoconductivity [2].

Many materials are used in orbital blowout fracture repair. These include autogenous bone (calvaria, iliac, maxilla and ribs), allografts such as metallic implants (titanium mesh, titanium plate), nonmetals such as Gore-Tex, silastic, silicone, methyl methacrylate and resorb able implants [5].

Periosteum, ear cartilage, rib grafts, mandibular and iliac bone grafts, and calvarial grafts are examples of autografts. The major drawback of autogenous bone grafts is donor site conflicts, which includes blood vessel and nerve damage, aesthetic disruption, gait disturbances, and donor site discomfort or pain [14].

Autologous bone has the disadvantages of tenderness of the donor site, various absorptions, and restrictions on the ability to obtain a desired contour. Homogeneous bone has a high resorption tendency and is susceptible to infection [9].

Various factors influence material selection for reconstruction of the orbital floor. The choice is based on the extent of the defect, the affection of several walls, conformity to internal contours, the existence of neighboring sinus cavities, restoration of an acceptable volume, avoidance of displacement, the potential for additional harm, restriction of adhesions or eye movements, early or late recovery [9].

The ideal material depends on many factors, including fracture characteristics, cost, patient choice, and the surgeon's experience. In this study, it was concluded that orbital mesh, titanium mesh, diced cartilage graft, and calvarial bone graft could be used [7].

PATIENTS AND METHODS

General data:

This retrospective and prospective study used a case series design in patients who underwent internal orbital reconstruction with a skull graft (external table) or titanium mesh (0.4mm thickness) at Sohag University Hospital and Luxor University Hospital for 2 years. 40 patients were divided into two equal groups.

- Group A: Includes 20 patients treated surgically using titanium mesh.
- Group B: Includes 20 patients receiving autologous bone grafts.

Inclusion criteria:

Unilateral orbital rupture fracture, contralateral orbit intact, over 16 years of age, images of sufficient quality to evaluate re-constructive material.

Exclusion criteria:

Patients who had blowout orbital fractures bilaterally (to allow comparing the injured versus unaffected side) and patients with severe facial fractures.

Titanium mesh will not be used in the following conditions: Children, severe enophthalmos, infection, medial blowout.

Patient preparation and surgical procedure:

Age, sex, side of damage, etiology, date of trauma, date of hospitalization, date of operation, surgical technique or techniques, reconstructive materials, and technique of stabilization were all provided by the patients' medical records.

I- *Group A:* The procedure will be done under general anesthesia, within 1-3 weeks after trauma. Sub-ciliary incision will be performed through the lower eyelid. Beginning with dissection of the soft tissue up to the infraorbital rim, then opening the periosteum as well as sub-periosteal layers deeply to the floor of the orbit, using a malleable retractor to raise the orbital tissues and gain insight to accurately identify the orbital fracture defect. After that, we start reducing the protruding orbital contents from side - to - side to prevent the damage of its content, identifying the stable defect boundaries to support the mesh, and manipulating the titanium mesh to suit size, form, and properly cover the defect.

Simulating the contours and slopes of the orbit's floor and medial wall requires careful consideration. Before surgically closing the incision, all cases underwent a forced-duction test, appropriate periosteal closure, and screw fixation of the mesh to the margin of the orbital (to ensure that the herniated orbital tissues are completely released).

II- *Group B:* A sub-ciliary incision is made through the lower eyelid under general anesthesia. The fracture site is exposed, the dis-placed contents of the orbit are repositioned, and bone defects are examined. It also deter-mines the shape and size of the bone graft. The cranial bones served as donor sites.

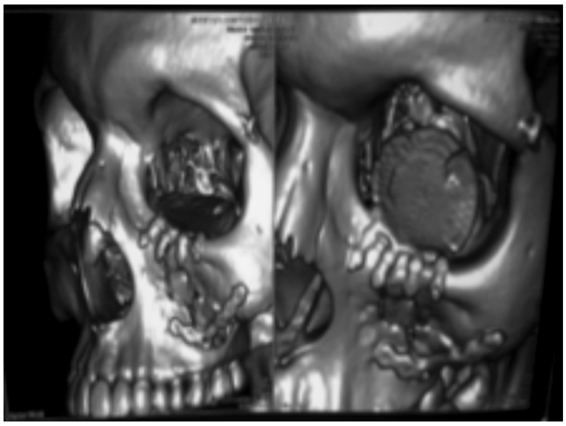
(A): Left orbital blowout with sun set appearance of the eye.

(B): Correction of downward gaze of the eye.

(C): Eposure of the orbital blowout.

(D): Customized titanium mesh fixed.

(E): 3D view showing orbital floor blowout.



(F): 3D view showing fixed mesh.

Fig. (1): Male patient 25-year-old, post traumatic left orbital blowout of 14 days ago. Reduction and fixation were done by Customized titanium mesh.

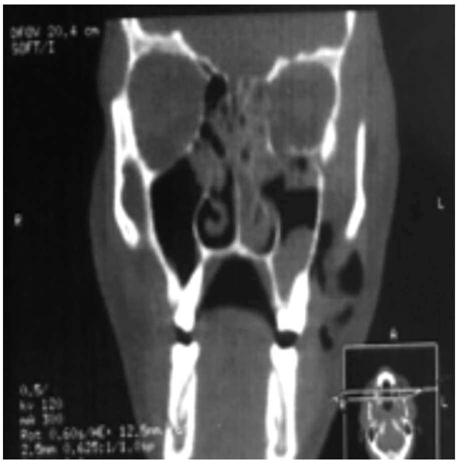
(A): Left orbital blowout.

(B): Correction of the left orbital blowout.

(C): Exposure of the orbital blowout.

(D): Calvarian bone graft placement.

(E): Coronal section showing orbital floor blowout.



(F): Coronal section after placement of calvarian bone.

Fig. (2): Male patient 34-year-old, post traumatic left orbital blowout of 10 days ago. Reduction and fixation were done by autogenous calvarian bone.

Statistical analysis:

The IBM SPSS statistical software, version 21, was used to conduct the statistical analysis. While categorical variables are presented using proportion and frequency, quantitative data are presented using the mean, median, min, and max as measures of variability, central tendency, and standard deviation, respectively. To investigate the significant link between two categorical variables, the chi-square test was utilized. To find differences of greater than 20% in quantitative parameters in same patient group, Fisher and Monte-Carlo exact tests were utilized. The Mann-Whitney U-test and Independent Samples *t*-test were used to identify significant differences in mean and median of numerical study variables between the two patient groups. To find statistically significant variations in mean quantitative variables across various time periods, a repeat measurement ANOVA test was used. We utilized Mauchly's sphericity test to determine whether or not the variance was homogeneous. The findings of the Huynh-Feldt test, which was performed in place of the more traditional F test, are considered significant. Following Bonferroni correction, pairwise comparisons were conducted using the corrected *p*-value.

All statistical tests were performed at the significance level of 0.05.

14 patients (28 male and 12 female; mean 30 year; age starts of 18 to 48 year) met the inclusion criteria.

14 fractures due to Aggression, 10 due to MCA, 12 due to fall and 4 to Sports. 16 of the fractures were on the right side and 24 on the left as shown in Table (1).

Table (2) lists the details of the relationship between autologous bone technique (preoperative and postoperative) and ophthalmic problems. There was no statistically significant difference in blind eye anomalies, but in the cases (diplopia, limited range of motion, restricted movement, decreased suborbital sensation and vertical myopia) it was significant. (Fig. 1).

Table (3) lists the details of the relationship between (preoperative and postoperative) with titanium mesh technology ophthalmic problems. There was no statistically significant difference in blind eye defects, but in cases (diplopia, limited range of motion, motor limitations, decreased suborbital anesthesia and vertical astigmatism) there was a difference. There was statistical significance between before and after surgery with titanium mesh and ophthalmic problems (Fig. 2).

Table (4) lists the details of the relationship between autogenous bone and titanium mesh. Preoperative ophthalmic problems were not statistically significant for all parameters. (Fig. 3).

Table (5) lists the details of the relation between Autogenous bone and titanium mesh Ophthalmological problems with post-operative show no any statistically significant for all data (Fig. 4).

Table (1): Demographic data distribution in study population.

	All cases	Autogenous bone	Mesh	*p*-value	Statistically significant
Total	40	20	20		
Cause of injury:					
Aggression	14	8	6	0.6857	N.S
MCA	10	4	6		
Falling	12	6	6		
Sports	4	2	2		
Side of injury:					
Right	16	9	7	0.7475	N.S
Left	24	11	13		

- Statistical test used: Fisher's test & Chi-Square test.
- *p*-value ≤0.05 considered statistically significant (95% confidence interval).

Table (2): Relation between (pre- and post-operative) with autogenous bone techniques ophthalmological problems.

	Pre-Operative	%	Post-Operative	%	*p*-value	Statistically significant
Autogenous bone Ophthalmological problems:						
Diplopia	11	55	1	5	0.0012	N.S
Movement restriction	8	40	0	0	0.0033	Sig.
Enophthalmos	9	45	2	10	0.031	Sig.
Infraorbital hypoesthesia	18	90	2	10	<0.0001	Sig.
Vertical dystopia	6	30	0	0	0.0202	Sig.
Blind eye	1	5	1	5	>0.9999	N.S

- Statistical test used: Chi-Square test.
- *p*-value ≤0.05 considered statistically significant (95% confidence interval).

Table (3): Relation between (pre- and post-operative) with titanium mesh techniques ophthalmological problems.

	Pre-Operative	%	Post-Operative	%	*p*-value	Statistically significant
Mesh Ophthalmological problems:						
Diplopia	10	50	1	5	0.0033	N.S
Movement restriction	5	25	0	0	0.0471	Sig.
Enophthalmos	10	50	2	10	0.0138	Sig.
Infraorbital hypoesthesia	16	80	2	10	<0.0001	Sig.
Vertical dystopia	8	40	0	0	0.0033	Sig.
Blind eye	0	0	0	0	>0.9999	N.S

- Statistical test used: Chi-Square test.
- *p*-value ≤0.05 considered statistically significant (95% confidence interval).

Table (4): Relation between [pre-operative Ankle-Hindfoot Scale (%)] with different techniques.

	Pre-Operative				*p*-value	Statistically significant
	Auto-genous bone	%	Mesh	%		
Autogenous bone Ophthalmological problems:						
Diplopia	11	55	10	50	>0.9999	N.S
Movement restriction	8	40	5	25	0.5006	N.S
Enophthalmos	9	45	10	50	>0.9999	N.S
Infraorbital hypoesthesia	18	90	16	80	0.6614	N.S
Vertical dystopia	6	30	8	40	0.7411	N.S
Blind eye	1	5	0	0	>0.9999	N.S

- Statistical test used: Chi-Square test.
- *p*-value ≤ 0.05 considered statistically significant (95% confidence interval).

Table (5): Relation between (post-operative Ankle-Hindfoot Scale) with different techniques.

	Post-Operative				*p*-value	Statistically significant
	Auto-genous bone	%	Mesh	%		
Autogenous bone Ophthalmological problems:						
Diplopia	1	5	1	5	>0.9999	N.S
Movement restriction	0	0	0	0	>0.9999	N.S
Enophthalmos	2	10	2	10	>0.9999	N.S
Infraorbital hypoesthesia	2	10	2	10	>0.9999	N.S
Vertical dystopia	0	0	0	0	>0.9999	N.S
Blind eye	1	5	0	0	>0.9999	N.S

- Statistical test used: Chi-Square test.
- *p*-value ≤ 0.05 considered statistically significant (95% confidence interval).

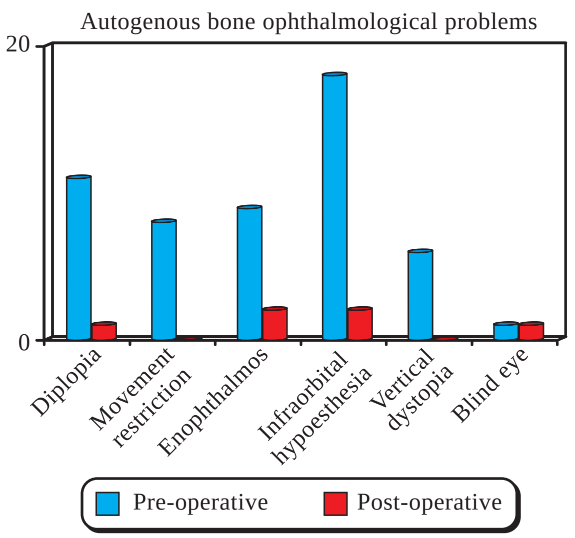


Fig. (1): Relation between (pre- and post-operative) with autogenous bone techniques ophthalmological problems.

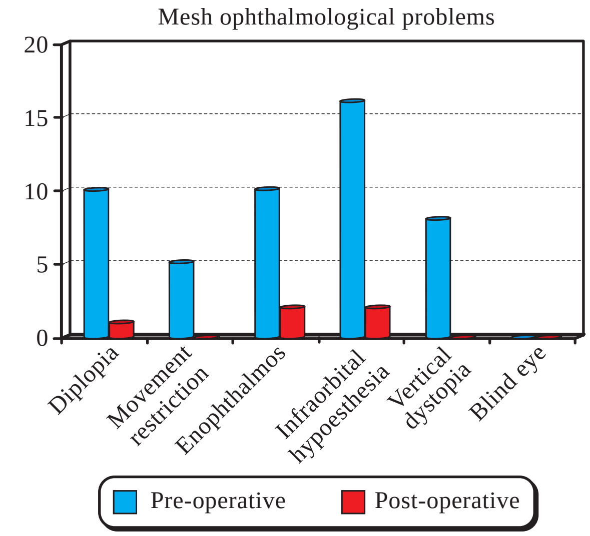


Fig. (2): Relation between (pre- and post-operative) with titanium mesh techniques ophthalmological problems.

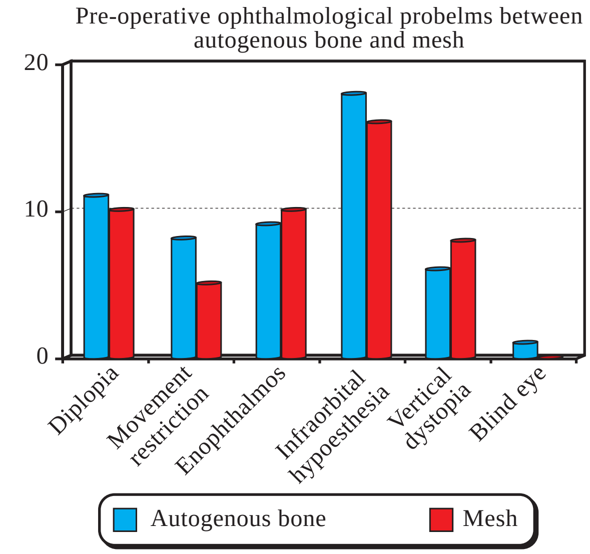


Fig. (3): Relation between [pre-operative Ankle-Hindfoot Scale (%)] with different techniques.

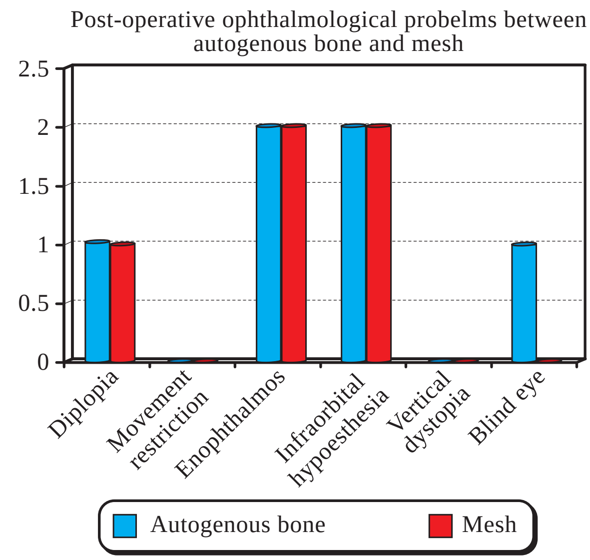


Fig. (4): Relation between (post-operative Ankle-Hindfoot Scale) with different technique.

DISCUSSION

Orbital fractures lead to severe post-traumatic hypo-ophthalmos and enophthalmos despite more effective treatment for complicated orbital fractures with virtually ideal anatomical procedures **[5]**.

Orbital reconstruction is difficult because when a fracture occurs, the bone wall is fractured and bone frag-ments may be missing. Therefore, it is very important to restore the lost bones. The debate is about the best implant for orbital reconstruction, as well as the indications and timing of surgery. (Cheek bones, maxilla, frontal bones) **[12]**.

Autogenous tissues have been used since the turn of the century. Autogenous grafts have down-falls such as being time-consuming, requiring an extra surgical site, and resorption of the grafts, despite the fact that they prevent the issues of infection that may be brought about with the use of artificial biocompatible materials. Despite this, compared to synthetic reconstructive grafts, autog-enous grafts still have a higher biocompatibility **[13]**.

To reconstruct the fractures at the floor of the orbit, a variety of materials including autogenous carti-lage, bone, and alloplastic implants have been employed. Due to the drawbacks of alloplastic materials that are non-resorbable and the challenges associated with extracting autogenous tissues, a new material is required **[14]**.

In this study, the mean age was 29.05 years for autogenous bone, the minimum and maximum ages were 18 and 40 respectively. For the titanium mesh, the minimum and maximum ages were 18 and 40 respectively. The age was 18 and the maximum age was 48, and it can be seen that the gender distribution is more concentrated in males than females.

In another study, males outperform females. This is consistent with previous studies.

In a research conducted in 2011 by Gabrielli et al., men predominated. The same findings are supported by a research conducted by Sakakibara et al., in 2009. According to another survey, the majority of patients are in their third and fourth decades of life **[15]**.

The other study showed that the complex orbital fracture had male predominance (73.9%), and the traffic accident (47.8%) is a leading cause, followed by industrious injury (30.4%) and fighting (17.4%) **[16]**.

In this study, the relation between Autogenous bone and titanium mesh with Side of injury show no any statistically significant of data.

Sukegawa S et al., recommended using the coronoid process as either a bone graft or to rebuild the orbital floor by comparing its morphology to that of the orbital floor using skulls. The findings of their investigation demonstrated a tight corre-spondence between the contour and dimensions of the right orbital floor and the lateral left cortex of the coronoid process, as well as the reverse **[17]**.

After reducing the fracture region on the left side, a titanium mesh (1.5mm) was fitted onto the orbit. The premade titanium mesh, which was precisely positioned underneath the orbital contents and designed to replicate the orbital structure by filling the orbital defect **[18]**.

In this study, the relation Autogenous bone and titanium mesh with Trauma-surgery interval show no any statistically significant of data.

There was no distinctive variation in clinical outcomes between the treatment of post-traumatic enophthalmia, diplopia, and sensory problems after orbital bone defect reconstruction utilizing allo-plastic materials, such as coral, silicone, PDS, titanium mesh, and autologous fresh bone grafts, such as the outer calvarial cortex, in the interesting clinical investigations conducted by Ellis and Tan and in a subsequent instructional review research by Potter and Ellis **[19]**.

Chunlei et al., evaluated the use of autologous maxilla to treat orbital floor defects following blunt facial trauma. They conducted a study in 41 patients who were treated for an orbital floor fracture with a bone graft from the anterior wall of the maxilla. At follow-up, none of the patients showed signs of orbital dystopia or implants or donor sites related complications. They concluded that the use of bone grafts from the maxillary frontal bone for orbital bed reconstruction is a very reliable and minimally complication method **[20]**.

Tom et al., suggested that large pore size of titanium mesh and extension from the floor to rim are risk factors for orbital apex syndrome. The intact periorbital provide smooth gliding surface between ocular structures and bony orbital wall. Accordingly, Tom treats one of two reported cases by placement of smooth suprafoil on the top of titanium mesh instead of mesh removal; another risk factor postulated is time between trauma and primary intervention **[21]**.

However, if there is more orbital damage, titanium mesh may move closer to the orbital apex, compromising the optic nerve. Therefore, the calvarial bone graft's capacity to resorb may be seen as a possible benefit **[21]**.

In this study, the relation between pre- and post-operative with autogenous bone ophthalmological problems show no any statistically significant in (blind eye) and data shows statistically significant in (diplopia, movement restriction, movement restriction, infraorbital hypoesthesia and vertical dystopia). But in case of relation between pre- and post-operative with titanium mesh ophthalmological problems also show no any statistically significant in (blind eye) and data shows statistically significant in (diplopia, movement restriction, movement restriction, infraorbital hypoesthesia and vertical dystopia) and in case of relation between autogenous bone and titanium mesh ophthalmological problems with pre-operative show no any statistically significant for all parameter. And in case relation between autogenous bone and titanium mesh ophthalmological problems with post-operative show no any statistically significant for all data.

As many study indicates, preoperative stereolithographic modelling and computer design conjunction with intraoperative imaging could be useful for planning and achieving an ideal autologous or homologous bone graft adaptation and for saving time in the operating room; all that, with good clinical outcomes when limited to small areas like the one presented in this case and significantly less costly that could be saved for the management of more complex ones **[22]**.

In his comparison of autologous bone, biodegradable mesh, and titanium, Kyoung advised not utilizing bone grafts because of the prolonged operating time and postoperative resorption of the graft that may be observed on CT scans **[23]**.

Although the variety of researchers indicated that using titanium in orbital operations may provide extremely gratifying outcomes, there have sometimes been instances of serious post-operative complications **[24]**.

In their study on the rebuilding of the orbital floor, Patrick et al., demonstrated the value of using bone graft from the mandibular symphysis. Retrospective research including 16 patients with solitary orbital blow out fractures was carried out. When the lesions were smaller than 2cm, symphyseal bone transplants were employed. As a result, patients had no complaints after surgery for an average of 12 months. They said the contours are suitable for use in reconstruction of orbital floor and are worth considering when considering autologous bone grafts for floor lesions less than 2cm **[25]**.

Nitin et al., provided good structural support within the orbit. Both orbital volume and stability are critical to correct dry eye syndrome and double vision. 100 patients who got implants like Nitin, 70% of which were held in place with a single screw, were the subject of a study by Garibaldi and colleagues. One instance of overcorrection and orbital hemorrhage related to the thickness of the implant was reported **[26]**.

Mario et al., reported cases of diplopia due to extraocular movement limitation and/or scarring eyelid retraction after orbital fracture repair with titanium implants. To avoid orbital adhesion syndrome, Mario et al., advise the use of non-porous, non-reactive implants is recommended for the treatment of orbital fractures with minimal eyelid incision and plate placement as far from the orbit and eyelid tissue as possible **[27]**.

In the absence of an implant-stabilizing which surround the bone or a distally landmark like a bone ledge, titanium may be the optimal implant for addressing significant anatomical abnormalities and globe malposition, according to Chun et al., A number of studies also came to the conclusion that fixation was necessary to minimize migrations, which might result in infections, scarring, fibrosis, diplopia, and even vision loss. Fixation could be more difficult if the orbital rim was joined. The bony parts might be secured with a titanium mesh **[28]**.

Atanu Barh et al., reported that complications occurred in nineteen percent of cases, including enophthalmos (3.7%), continuous diplopia (3.2%), orbital infection (0.5%), ectropion (2.6%), and hematoma inside the orbit (3.2%). Nonetheless, a recent retrospective analysis revealed no statistical relationship between the date, approach, and material of the surgery and the end diplopia result; follow-up period, or frequency of follow-up visits **[29]**.

Moustafa Alkhalil and J. Joshi Otero who reconstructed 51 orbits with titanium implant reported only 1 case of enophthalmos with no infection which proves that titanium has very good biocompatibility and incidence of infection is very rare which is similar to the results we obtained in our study **[30]**.

Bilge et al., observed a decrease in postoperative findings of enophthalmos and diplopia but came to the conclusion that using a custom-made titanium mesh rather than a calvarial bone graft was the best option for restoring the accurate preoperative orbital volume **[31]**.

An 18 to 20% increase in the bone orbital volume in a fractured floor of the orbit compared to an unfractured orbit may be a need for surgery since there is a greater risk of enophthalmos & consequent diplopia **[32]**.

Agata found no differences between immediate and postponed bone grafting in a prospective analysis of nine patients who had repair of segmental mandibular lesions. Both groups showed a 100% graft integration rate. It should be emphasized that all of his patients, with the exception of one, did not have significant soft tissue injuries after having their mandibles cut due to benign tumors or trauma **[33]**.

In addition to reporting decreased revision rates (19.2 vs. 26.7%) for immediate grafts and postponed grafts, Gander et al., observed no difference in rates of infection (26.9 vs. 26.7%) between immediate and delayed grafts. A porous polyethylene-coated titanium mesh is placed over the medial and inferior orbital fractures intraoperatively using a 3D printed skull model. It should be noted that they created a shape by mirroring the orbit. 95.5% of the patients in the research group of patients using 3D-printed models did not experience dry eyes, whereas 4 did.

In the control group, 5% had mild dry eye syndrome and diplopia, whereas 86.8% had no dry eye syndrome, 7.9% mild dry eye syndrome, and 13.2% had double vision **[34]**.

Conclusion:

Autologous bone graft does not cause immunological problems, but the donor site is limited. There may also be problems related to pain in the second site, mismatch of mechanical properties of the host bone, and tendency to resorption. Autogenous bone grafts in experienced hands can be used with minimal morbidity and even if resorbed, a fibrous tissue does the job. Titanium mesh, a synthetic biomaterial, is an expensive but good alternative and can overcome these limitations.

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