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RESEARCH ARTICLE

OUTCOME OF 3D RECONSTRUCTION IN ORBITAL AREA AFTER LONG PERIOD FOLLOW UP IN A MILITARY HOSPITAL IN SANA'A CITY, YEMEN

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Abstract

Background and aims: Long-term follow-up after 3D reconstruction in the orbital area show improvements in cosmetic appearance, ocular motility, and resolution of issues like enophthalmos and diplopia, with some residual symptoms and rare complications. The study aims to assess clinical outcomes of 3D printing for reconstructing orbital bone defects in patients receiving PEEK and PMMA implants.

Materials and methods: A study conducted at the Military Hospital in Sana'a, Yemen, involved seven patients with orbital fractures who underwent 3D-printed orbital bone repair. Conventional treatments had previously failed in these patients. Examinations included computed tomography (CT), functional assessments, and preoperative evaluations. GOM and ATOS technologies were used to develop customized 3D-printed implants, and general anesthesia was used during the surgeries.

Results: The group, consisting of 100% males and 0.0% females, had a mean age of 30.3 years. Six cases showed positive outcomes, while the third case failed due to issues like loose orbital rim, blocked tear duct, allergies, and patient disengagement. The study reveals that 42.9% of patients underwent orbital bone reconstruction surgery using 3D printing technology, with 42.9% experiencing pain, 7.7% experiencing aesthetic deformity, and 23.6% experiencing infection. The reconstruction material used was polyether ether ketone (PEEK), polymethyl methacrylate (PMMA), or poly-cule. The study found that 28.6% of patients had fractures in the mandible, maxilla, nose, zygomatic bone, orbit, and frontal bone. Comminuted fractures were found in all seven patients, and no simple, compound, or complex fractures were recorded. The study found that 57.1% of patients were highly satisfied with their surgical results, with 14.3% satisfied and 28.7% dissatisfied, with all patients demonstrating good quality of life.

Conclusion: The study found seven patients had imperfect orbital fractures, with a third having fractures in various areas. Comminuted fractures were common, with high instability rates. Most patients were satisfied with their surgical results and quality of life, supporting the use of 3D navigation for complex orbital reconstruction.

Keywords: 3D reconstruction, implant, orbital fractures, orbital reconstruction, outcome, PEEK, PMMA, reconstructive surgical procedures, Yemen.

INTRODUCTION

There are two types of orbital fractures: complex orbitofacial fractures and orbital fractures. Fractures that only affect the orbit's inner walls and do not cause the orbital margins to shift are known as confined or simple orbital fractures. They fall into three general categories: impact fractures, which are less frequent, burst fractures, and linear fractures. There are several types of orbital fractures that affect the rest of the craniofacial skeleton, including orbitofacial fractures (Le Fort II fractures {medial wall and floor} and Le Fort III fractures {medial wall and lateral wall}), skull, orbital, facial, and full-face fractures (upper, middle, and lower facial skeleton), and complex zygomatic-maxillary fractures (involving the lateral wall and lateral orbital floor)[1,2]. For any significantly displaced orbital fractures (orbital rims and/or walls) at risk of developing post-traumatic deformity, such as enophthalmos and residual diplopia, orbital fracture repair is recommended with the appropriate risk rating. The only exceptions are trapdoor or linear fractures, which are typically seen in children and young adults and do not entrap the inferior rectus-intermuscular septum complex or medial rectus. Burnstine provided an evidence-based procedure for ocular blow out fractures that included entrapment and major fractures when latent enophthalmos was imminent as indications for emergent surgery[2,3]. It is preferable to observe small fractures with minimal diplopia and uninjured extraocular movements. In those observational cases, additional surgical intervention is performed when edema subsides and diplopia persists or enophthalmos manifests clinically[4]. Additional reasons for surgery include trismus, telecanthus and facial deformity from a naso-orbito-ethmoid (NOE) fracture in a patient who is worried about the abnormalities, or increased mid-face breadth or malar flattening from a zygomatico-maxillary (ZMC) fracture[4].

With an incidence of 3–32%, orbital wall fractures are a frequent consequence of face trauma[5]. Significant enophthalmos and limiting diplopia are common surgical indications for orbital wall fracture repair[6]. In order to repair the defect and stop the orbital tissues from herniating again, an orbital wall implant is typically placed during surgery[7]. Restoring the internal orbit's normal anatomical relationships while preventing implant and procedure-related problems is the primary objective of the surgery. However, because orbital architecture varies from person to person, it is difficult for surgeons to restore orbital wall deformities precisely. The orbit's 3D structure features intricate concavities and convexities in its contours, making it more than just a straightforward cone. Consequently, it is challenging and time-consuming to manipulate implants intraoperatively to fit these complex geometries, particularly for novice surgeons. A promising answer to this problem is provided by developments in 3D printing technology. Our earlier research showed that effective orbital volume restoration may be achieved by bending titanium-embedded polyethylene 2D implants using a 3D-printed mold[8]. Additionally, a variety of bone abnormalities can now be repaired thanks to recent advancements in direct printing technology using biocompatible materials[9-11]. For the repair of orbital wall fractures, we have used a polycaprolactone (PCL) patient specific implant (PSI) that was 3D printed.

SUBJECTS AND METHODS

Study Design: A serial clinical follow-up study.

Study population: Every patient who visits the military hospital between January 1, 2024, and July 31, 2025 (the time allotted for clinical work for the board's degree).

Data collection procedure: Every patient who satisfied the pre-established inclusion requirements was admitted right away to the Yemeni Military Hospital's OMFD. They received a thorough explanation of the study's methodology there, and their signed informed permission was promptly acquired. Relevant demographic information, including age, medical history, behavioral habits, and contact details, is painstakingly recorded on a form designed specifically for this purpose. A comprehensive assessment of the patient's medical history, a meticulous clinical examination, and a comprehensive radiological evaluation which comprised a standard CT scan with 3D reconstruction, including axial and coronal views, as a preoperative procedure were the first steps in the diagnosis process. Additionally, every patient included in the study underwent meticulous laboratory testing. Using 3D printing technology, these seven patients underwent orbital repair as part of their treatment. Seven patients with orbital bone deformities who had previously received ineffective conventional treatments were enrolled in this exploratory trial. All participants provided informed consent. Preoperative assessments included medical history reviews, imaging studies (CT scans), and functional assessments. Custom 3D-printed implants were designed using GOM; ATOS, Braunschweig, Germany, based on high-resolution CT scans to create accurate models of the defects. The implants were fabricated using 3D printing technology (FDM and SLA) with biocompatible materials such as PMMA in six cases and PEEK in one case as the material for facial augmentation and skull reconstruction. Surgeries were performed under general anesthesia, with failed grafts removed and the 3D-printed implants placed and secured with screws and plates. Postoperative care included monitoring for complications and follow-up assessments at weeks 1, 2, 8, 12, and 16, with some being followed for more than a year.

Statistical Analysis: SPSS version 20 (SPSS Inc., Chicago, IL, USA) statistical software was used to analyse the data. Frequency distribution, percentages, and proportions were used in descriptive analyses.

RESULTS

Table 1 displays the age and gender distribution of seven patients who had orbital reconstruction at the Military Hospital in Sana'a City utilising 3D printing technology. The group's mean age was 30.3±8.8 years, and the patients' ages ranged from 24 to 44 years. There are 100% men and 0.0% women.

The Table 2 shows the last follow-up and outcomes of orbital fracture patients who underwent orbital reconstruction using 3D printing technology. Six cases demonstrated good results and were fully satisfied with both the physicians and patients, with no complaints. In one case (the third case), the orbital reconstruction was unsuccessful due to a loosened and exposed orbital rim, a blocked tear duct, a defective specimen handling and preparation during the procedure, an allergy to the prosthetic ball impression one year after placement, and the patient's lack of cooperation. Furthermore, the fifth case required a second surgery to repair the soft tissue using plastic surgery. Table 3 shows the etiology of orbital fractures in patients who underwent orbital reconstruction using 3D printing technology. In 42.9% the cause was G.S.I, and 57.1% bomb explosion and none due to falls from height or RTA (0.0%).

Table 4 shows the 3D orbital bone defect reconstruction material, where polyether ether ketone (PEEK) was used in only one case (14.3%) while polymethyl methacrylate (PMMA) was used in 5 cases (71.4%) and one case poly-cule was used. Table 5 shows the quality of life, social interaction, and emotional well-being of the study patients. Regarding quality of life, six patients had good outcomes and one had poor outcomes. Similarly, regarding social interaction, all patients had good outcomes, six patients had good emotional well-being, and one patient had poor emotional well-being. Table 6 shows the follow-up complaints of patients who underwent orbital reconstruction surgery using 3D printing technology. Pain was reported in 42.9% of patients, all of whom (7 patients) still suffered from aesthetic deformity, and 23.6% reported infection.

Table 1: Gender and age distribution of seven patients who underwent orbital area reconstruction using 3D printing technology.

Characters	Number (%)
Sex	
Male	7 (100)
Female	0 (0.0)
Age in Years	
Twenties	3 (42.9)
Thirties	2 (28.6)
Forties	2(28.6)
Mean	30.3 years
SD	8.8 years
Median	27.5 years
Mode	24 years
Min to Max	24 - 44 years

Table 2: Time of last follow up and the outcome among orbital fractures patients who underwent maxillofacial reconstruction using 3D printing technology.

No	Time of follow up	Outcome at the last time seen
Case 1	17 months	Well
Case 2	22 months	Well
Case 3	12 months	Failure to success of peek due to dehiscence infra-orbital rim and expose of peek. Lachrymal duct leakage. Fault of manipulation and prepare of peek during operation. Allergy of impression of artificial globe after a year. Uncooperative patients.
Case 4	8 months	Well
Case 5	11 months	Well
Case 6	9 months	Well
Case 7	5 months	Well

Table 7 shows the fracture locations of patients who underwent orbital reconstruction using 3D printing technology. Fractures occurred in the mandible (14.3%), the maxilla (28.6%), the nose (14.3%), the zygomatic bone (57.1%), the orbit (100%), and the frontal bone (28.6%).

Table 3: Etiology of maxillofacial fractures in patients who underwent orbital reconstruction using 3D printing technology.

Etiology	No (%)
G.S.I	3 (42.9)
RTA	0 (0)
Bomb explosion	4 (57.1)
Fall from height	0 (0)

Table 4: Material of the 3D reconstruction of orbital bone defects.

Materials	Number (%)
Polyether ether ketone (PEEK)	1(14.3)
Polymethyl methacrylate (PMMA)	5 (71.4)
Poly cule	1 (14.3)
Total	7 (100)

Table 8 shows the types of fractures in patients who underwent orbital reconstruction using 3D printing technology. Comminuted fractures were found in all seven patients, maxillary sinus fractures in one case, and no simple fractures, compound fractures, or complex fractures were recorded. Table 9 shows the orientation of jaw and facial fractures in patients who underwent maxillofacial reconstruction using 3D printing technology. Unilateral fracture orientation was found in 71.4% of patients, segmental fracture orientation in 28.6%, and partial fracture orientation in 14.3% of cases.

Table 5: Quality of life, social interaction, and emotional well-being of patients participating in the study.

Complains	Number (%)
Co-operative with medical staff	6 (85.7)
Quality of life	
Bad	1(14.4)
Good	6(85.7)
Excellent	0(0)
Social interaction	
Bad	0(0)
Good	7(100)
Excellent	0(0)
Emotional well-being	
Bad	1(14.3)
Good	6(85.7)
Excellent	0(0)
Total	6(100)

Table 6: Complaints of patients who underwent orbital reconstruction using 3D printing technology after follow up.

Complains	Number (%)
Pain	3 (42.9)
Aesthetics deformity	7 (100)
Limited moth opening	2 (28.6)
Difficulty to eat	3 (42.9)
Infection	2 (28.6))
Total	7 (100)

Table 7: The fracture sites for patients who underwent orbital reconstruction using 3D printing technology.

Sites	Number (%)
The mandible	1 (14.3)
The maxilla	2 (28.6)
The nose in	1 (14.3)
The cheekbone (zygoma)	4 (57.1)
The orbit	7 (100)
The frontal	2 (28.6)
Total	7 (100)

Table 10 shows the types of previous procedures and the reasons for their failure in orbital fracture patients who underwent orbital reconstruction using 3D printing technology. Based on the types of procedures, 85.7% of patients underwent tissue debridement, and 14.3% bone grafting.

Table 8: Types of fractures in patients who underwent orbital reconstruction using 3D printing technology.

Types	Number (%)
Comminuted fractures	7 (100)
Simple fractures	0 (0)
Maxillary sinus fractures	1 (14.3)
Compound-complex fractures	0 (0)
Total	7 (100)

Table 9: The orientation of jaw and facial fractures in patients who underwent orbital reconstruction using 3D printing technology.

Distant	Number (%)
Unilateral fractures	5 (71.4)
Segmental fractures	2(28.6)
Displacement fractures	0(0)
Tripod fractures	0(0)
ZMC	1(14.3)
Total	7(100)

Based on the reasons for failure of the first previous procedure, the instability rate was 85.7%, with 100% due to inadequate fixation, and 28.6% due to infection. Table 11 shows the effect of the injuries on eye tissues among orbital fractures patients who underwent orbital reconstruction using 3D printing technology. Lamina papyrececa was effected in 42.9%, orbital rim effected in 42.9% of the patients, also lateral wall was effected in 42.9% of the patients. Medial wall Floor effected I 14.3% as floor effected in 14.3%. Rupture of eye globe occurred 42.9% of the patients, also Super orbital rim effected in 14.3%, and Zygomatic bone and arch in 14.3%. Table 12 shows the follow up after surgery among orbital fractures patients who underwent orbital reconstruction using 3D printing technology.

Table 10: Types of past operation and causes of failure in the previous operation for orbital fractures patients who underwent orbital reconstruction using 3D printing technology.

Characters	Number (%)
Types of operation	
Debridement operation	6 (85.7)
Bone graft	1 (0)
Causes of failure of first operation	
Instability	6 (85.7)
Insufficient	7 (100)
Infection	2 (28.6)
Total	7 (100)

Table 13 shows the postoperative evaluation and recovery experience among maxillofacial fracture patients who underwent maxillofacial reconstruction using 3D printing technology. 57.1% of patients were highly satisfied, 114.3% satisfied, and 28.7% were satisfied with the surgical results. However, 14.3% were dissatisfied. Table 14 shows the postoperative assessment and quality of life of orbital fracture patients who underwent orbital reconstruction using 3D printing technology.

Table 11: Effect of the injuries on eye tissues among orbital fractures patients who underwent orbital reconstruction using 3D printing technology.

Characters	Number (%)
Lamina papyrececa	3 (42.9)
Orbital rim	3 (42.9)
Lateral wall	3 (42.9)
Medial wall Floor	1 (14.3)
Floor	1 (14.3)
Roof	0 (0)
Isolated orbital	0 (0)
Rupture of eye globe	3 (42.9)
Super orbital rim	1 (14.3)
Zygomatic bone and arch	1 (14.3)
Total	7 (100)

All patients showed good social interaction, while 87.7% demonstrated good mental health and a satisfactory quality of life. Table 15 shows the final postoperative evaluation of orbital fracture patients who underwent orbital reconstruction using 3D printing technology. 100% of patients demonstrated improved facial symmetry, good bone fragment reduction, and proper alignment. However, only 14.3% reported pain at the last follow-up.

DISCUSSION

Results of orbital wall fracture repair using a 3D-printed PSI were described in the current retrospective study, with 57.1% of patients expressing strong satisfaction, 14.3% expressing satisfaction, and 28.7% expressing satisfaction with the surgical outcome. Clinical results were acceptable and there were no problems following surgery. Furthermore, over the course of more than six-month follow-ups, during which 100% of patients showed improved facial symmetry, good bone fragment reduction, and proper alignment, computer-aided volumetric and morphometric analyses showed that the repaired orbit is symmetrical to the contralateral normal orbit in size and contour. At the most recent follow-up, however, only 14.3% of respondents reported pain. 3D printing applications are beneficial in patient-specific surgery, particularly in structurally challenging areas[9,12-21].

Table 12: The follow up after surgery among orbital fractures patients who underwent orbital reconstruction using 3D printing technology.

Characters	Follow up after					
	1 week	2 weeks	8 weeks	12 weeks	16 weeks	Last follow up
Wound dehiscence	1 (14.3)	3 (33.3)	2 (28.6)	2 (28.6)	2 (28.6)	1(14.3)
Facial asymmetry	7 (100)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Infections	1 (14.3)	1 (14.3)	1 (14.3)	0 (0)	0 (0)	0 (0)
Instability	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
allergy	0 (0)	0 (0)	1 (14.3)	1 (14.3)	1 (14.3)	1(14.3)
Scar	1 (14.3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Antibiotics	4 (57.1)	4 (57.1)	1 (14.3)	0 (0)	0 (0)	0 (0)

Direct printing or molding methods can be used to create orbital PSI with 3D printing technology. More intricate structures may generally be reproduced using the direct printing method as opposed to the molding method[22]. Direct 3D printing can be done in a number of ways, including FDM, selective laser sintering, and stereolithography. High-resolution CT scans were used to generate precise models of the flaws in the current investigation, which involved designing unique 3D printed implants utilizing GOM; ATOS, Braunschweig, Germany.

Table 13: Post-operative assessment and recovery experience among orbital fractures patients who underwent orbital reconstruction using 3D printing technology.

Characters	Number (%)
Satisfied for results	
Very satisfied	4 (57.1)
satisfied	1(14.3)
Natural	2(28.7)
dissatisfied	1(14.3)
Total	7(100)

Table 14: Post-operative assessment and quality of life among orbital fractures patients who underwent orbital reconstruction using 3D printing technology.

Characters	Number (%)
Social interaction	7 (100)
Emotional well being	6(85.7)
Satisfied quality of life	6(85.7)
Total	7(100)

For craniofacial augmentation and reconstruction, the implants were made using 3D printing technology (FDM, SLA) and biocompatible materials like PMMA in five cases and PEEK in one. Because FDM is a straightforward, low-cost technology that can be employed on a variety of materials, including bioabsorbable polymers, its usage in the biomedical industry has grown[18,23]. An FDM-generated orbital implant was found to be effective in a prior study[24], but it was a population-based implant that could not be specifically tailored to each patient's orbital features. In the majority of orbital wall fracture cases, repair utilizing the traditional “manual cutting and bending” method with 2D implants is difficult due to the structural intricacy and curvature of the orbital walls[25]. Several sessions of trial-and-error implant customization are necessary for the reconstruction, and the experience of the surgeons affects the surgical results. Theoretically, orbital reconstruction utilizing a 3D-printed PSI may offer a number of advantages over reconstructions using traditional techniques, even if this study is not a comparison one[26].

Table 15: Final Post-operative assessment among orbital fractures patients who underwent orbital reconstruction using 3D printing technology.

Characters	Number (%)
Improving facial symmetry	7 (100)
Experience pain	1 (14.3)
Good bone segment reduction	7 (100)
Proper alignment	7 (100)

As indicated in Table 12, our results indicated no or few issues. These findings are consistent with a meta-analysis study that found that 3D-printed models are better than free-hand-shaped implants for precise orbital wall restoration with fewer difficulties[26]. Furthermore, in cases of mixed inferior and medial wall fractures, particularly those involving the inferomedial bony strut, it may not be able to entirely reproduce the original curvature and stability using this classical approach[27].

All seven patients in the current investigation had comminuted fractures, one had maxillary sinus fractures, and no simple, compound, or complex fractures were noted (Table 8). According to earlier research, patients with combined wall fractures experienced worse postoperative diplopia in terms of incidence, deviation angle, and Hess area ratio than patients with single-wall fractures[28-30]. According to other research, mixed wall fractures had a higher postoperative OVR than single-wall fractures[31,32]. Our findings demonstrated that, for combined wall fractures, 3D-printed PSIs allow for small volume changes and good clinical outcomes without diplopia, comparable to those for single-wall fractures.

Of the patients in the current study, 42.9% had pain, 100% had a cosmetic abnormality, and 28.6% had a bacterial infection. These results are consistent with earlier reports that facial bone fractures can cause pain, bruising, and swelling of the surrounding tissues, just like other fractures. These symptoms can even appear when there are no fractures. Severe nosebleeds may be linked to maxillary, skull base, or nasal fractures[33]. Swelling, bruising, and nose deformity can all be linked to nasal fractures[34]. Fractures are suggested by facial deformities such as depressed cheeks or misaligned teeth. Additionally, asymmetry may indicate nerve injury or facial fractures[35]. People with an orbital fracture often experience pain and difficulty opening their mouths and may experience numbness of the lip and chin[36]. Also with Le Fort fractures, the mid-face may move relative to the rest of the face or skull[37].

When looking at the causes of injuries in the current study, G.S.I. accounted for 42.9%, bomb explosions for 57.1%, and falls from height or RTAs for 0%. These results are different from those that have been documented in other parts of the world, where facial trauma in children[36,38] and adults[39] is frequently caused by mechanisms of damage such as falls, attacks, sports injuries, and auto accidents. Indirect attacks and strikes from fists or objects are also common causes of facial damage[33,40]. In our study, facial trauma was primarily caused by war-related injuries, such as explosions and gunshot. Animal attacks and work-related injuries such industrial accidents[41] are additional causes. One of the main causes of facial injuries is motor vehicle trauma, which typically happens when the face strikes an interior component of the car, such the steering wheel[42]. Furthermore, when airbags deploy, they may result in facial lacerations and corneal abrasions.

Taking into account the fracture sites, the mandible (28.6%), maxilla (28.6%), nose (14.3%), zygomatic bone (57.1%), orbit (100%), and frontal bone (28.6%) all experienced fractures in the current study (Table 7). These results are consistent with other reports that found the mandible, maxilla, and nasal bone (nose) to be the most frequently impacted facial bones. The mandible's ossicle, body, angle, ramus, and condyle are all susceptible to breaking[36]. The zygoma (cheekbone) and frontal bone (forehead)[43] are other fracture sites. Fractures can also occur in the bones that make up the orbit and the palate.

With the goal of avoiding bone grafting and cutting down on surgical time, this prospective study used PEEK and PMMA materials to 3D print orbital bone defects caused by various injuries and assess the related complications, evaluation experience, recovery, and quality of life following surgery. This concept is similar to the use of HA bioceramic blocks and particles that were already utilized in orbital surgery in the 1980s[44,45]. It was challenging to stop these particles from migrating, nevertheless. PSIs can now be created using these bioceramic materials. For the restoration of ocular bone abnormalities, HA bioceramic PSIs offer a volumetrically stable scaffold made of biocompatible material[46]. Regardless of the material, PSIs outperform conventional implants in terms of stability, implant-bone contact, fit correctness, and decreased surgical time and infection risk[47-49]. Accuracy is improved, especially with surgical navigation[49]. Our study's findings have validated earlier information.

Patients in this study received preoperative treatment utilizing traditional surgical techniques before undergoing maxillofacial reconstruction using 3D printing technology. 85.7% of patients had tissue debridement, and 14.3% had bone grafting, according to the types of operations performed. According to the causes for the first procedure's failure, the instability rate was 85.7%, with 100% of the difficulties resulting from insufficient fixation and 28.6% from infection. However, these issues vanished once they had reconstruction utilizing 3D printing technology with implants made of PEEK and PMMA. Bone grafting is not necessary with biomimetic bioceramic fillings[50]. They are osteoconductive, and the gyroids' big pores can guide bone cells and promote osteogenesis and fibrovascular development in a lab setting[46]. In the six cases, osseointegration was not objectively evaluated on CT scans 16 weeks post-surgery. Nonetheless, in the clinical cases conducted by Verbist*et al.*[49], the bioceramic fillings and the bone showed complete osseous contact and indications of bone growth[51-53]. This shows that the area surrounding the implant is mineralizing, fibrovascularizing, and mending well. Because bioceramic fillings are used internally rather than externally, they have shown advantages. This has produced a very pleasing aesthetic outcome in this crucial anatomical region. A longer follow-up time of up to 12 months is necessary to be able to see distinct radiographic indications of osseointegration[54,55].

Physicians and patients expressed great satisfaction with the outcomes of the current study's post-operative evaluation and recovery experience among patients with orbital fractures who had orbital reconstruction utilizing 3D printing technology. 14.3% of patients expressed satisfaction, and 57.1% expressed strong satisfaction. These results are consistent with a study that concluded that “3D printed bioceramic implants have great potential in orbital reconstruction surgery” after comparing 3D printing technology for orbital reconstruction with conventional surgery and bone grafts. Numerous applications are possible, and research indicates that these innovative implants offer several benefits over conventional techniques in terms of biocompatibility and biomechanical behaviour. A longer follow-up period is necessary in order to radiographically evaluate the osseointegration progress. However, due to their higher osseointegration ability and biocompatibility, we recommend their usage in load-sharing anatomical systems for reconstruction or cosmetic purposes. Further research is needed to evaluate the long-term effects of this intriguing biomaterial[51-53,56].

CONCLUSIONS

According to the study's findings, seven patients suffered from incomplete orbital fractures. The mandible, maxilla, nose, zygomatic bone, orbit, and frontal bone were fractured in one-third of the patients, according to the study. All seven patients had comminuted fractures; no simple, compound, or complicated fractures were noted. The rate of instability was high. The lamina papyrececa, orbital rim, lateral wall, medial wall floor, and eye globe were the most frequently fractured areas in the orbital region. According to the study, the majority of patients expressed great satisfaction with the outcomes of their surgeries, and every patient showed a decent quality of life. To sum up, this study offered level II evidence in favor of using 3D navigation to enhance surgical results in intricate orbital reconstruction.

Limitations of the study

The study analyzed a specific group of materials used in bone reconstruction in maxillofacial surgery, focusing on the eye socket. Radiolucent materials and insufficient thickness of polymethyl methacrylate (PMMA) made monitoring and evaluation challenging. The study also, faced difficulties in achieving optimal soft tissue alignment and thickness, potentially leading to selection and publication bias.

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AUTHOR'S CONTRIBUTIONS

Al-Sharif WKA: formal analysis, conceptualization, data organization, and clinical and laboratory examinations to obtain a board's degree in Oral and Maxillofacial Surgery. **Al-Rahbi LM:** supervised the clinical work and approved the final version. **Al-Ashwal AA:** reviewed the article, and approved the final version. **Al-Shamahy HA:** reviewed the article, and approved the final version. Final manuscript was checked and approved by all authors.

DATA AVAILABILITY

Upon request, the accompanying author can furnish the empirical data used to bolster the findings of the study.

CONFLICT OF INTEREST

There are no conflicts of interest in regard to this project.

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