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COMPARISON BETWEEN TITANIUM MINI PLATES VERSUS THREE-DIMENSIONAL TITANIUM PLATES FOR FIXATION OF PALATAL FRACTURES

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ABSTRACT

OBJECTIVE: *To compare the efficacy of 3-dimensional titanium plates versus mini titanium plates for the management of palatal fractures.*

METHODOLOGY: *The randomized controlled trial was conducted in the Department of Dental Surgery at Liaquat University of Medical and Health Sciences (LUMHS), Jamshoro. The sample of 106 patients (53 in each group) selected using non-probability consecutive sampling. Patients aged 18–45 years of either gender who presented with isolated palatal fractures or palatal fractures associated with other facial fractures were included in the study. Patients were divided into two groups via lottery method: Group A treated with three-dimensional titanium plates and Group B with conventional miniplates. Both groups underwent surgical fixation under general anesthesia. Postoperatively, patients were prescribed standard antibiotics and analgesics for three days and were monitored clinically and radiologically at intervals of one week, one month, and three months. Efficacy was assessed at the final visit, 12 weeks postoperatively. SPSS version 26.0 was used to analyse the statistical data.*

RESULTS: *The mean age of the participants was noted as 30.13 ± 5.14 years in the 3-DTM group and 31.30 ± 5.51 years. Gender distribution showed that 90.6% male participants in the 3-DTM group and 81.1% in the CTM group, while female participation was 9.4% and 18.9%. The 3-DTM group demonstrated significantly higher efficacy, with 73.6% achieving successful outcomes compared to 34.0% in the CTM group. The odds ratio for efficacy with 3-DTM was 5.417 (95% CI: 2.352–12.476), and this difference was highly statistically significant (p = 0.0001).*

CONCLUSION: *The study demonstrated that 3D titanium plates were significantly more effective than mini titanium plates in stabilizing palatal fractures, ensuring better fracture stabilization, occlusal alignment, and anatomical reduction with fewer complications. More well-controlled prospective clinical trials are needed to validate the current findings.*
KEYWORDS: *3D titanium plates, Palatal fractures, Mini titanium plates, Maxillofacial Injuries, Anatomical Reduction, Titanium fixation.*

INTRODUCTION

In 1901, Rene Le Fort investigated maxillary fracture patterns and discovered palatal fractures. These injuries are most common with midfacial or panfacial fractures and rarely occur in isolation [1,2]. They cause 9–13.2% of Le Fort fractures [3]. The hard palate supports the seven craniomaxillofacial buttresses [4]. The maxilla's palatine and horizontal bones are connected. The lower face's three-dimensional morphology depends on the hard palate's width, depth, and mandible length [5]. The palatal bone thickens anteriorly and thins towards the soft palate [6]. The sagittal and parasagittal areas are narrow, while the alveolus can be 12–14 mm thick. The typical palatal platform thickness is 4.5 mm [7-9]. Wrinkling of the midface, palatal ecchymosis in closed fractures, and upper lip or palatal mucosa laceration in open fractures are characteristic symptoms of palatal fractures [1]. In displaced fractures, incisor teeth may fall out or the occlusal connection breaks [3]. Various methodologies have been used to describe the pattern of palatal fractures in the literature. Sagittal, transverse, and comminuted fractures of the palate [10] are the three types. The CT-based classification method includes seven classes: anterior, posterior, sagittal, parasagittal, para alveolar, complicated, and transverse fractures [11]. Classifications help physicians locate anatomical structures but not make management decisions. Closed reduction, anterior treatment, anterior and palatal treatment, and combination treatment are the four classes of palatal fractures that were proposed for care [12]. Plate fixation of the alveolar process in isolation or with inter-molar wiring, combined splint and inter-molar wiring, mesh fixation, and external plate fixation of the palatal vault are listed as methods for fixing palatal fractures [13]. These techniques have drawbacks, including difficulty occluding, correct stability and reduction of fractures, speech disturbance, and dental hygiene maintenance. The usage of 3D plates solves these difficulties [14]. Placing the alveolus and pyriform aperture, as well as firm fixation of the maxilla's medial and lateral buttresses and palatal vault, are recent comprehensive therapies for palatal fractures [3]. A study recommended plate fixation of the alveolar ridge and external fixation of the palatal vault with 2-mm miniplates screwed into the hard palate above the mucosa. However, cleaning was problematic, causing infection, mucosal necrosis, and fistulas. 3D plates help prevent these issues [14]. Three-dimensional plates feature two bars that can retain fracture fragments [14]. Good reduction and stability, improved results in partially and fully edentulous patients, less speech and feeding disturbance, and no postoperative intermaxillary fixation are benefits of 3D plates. On extensive literature search, we found no studies specifically comparing 3D titanium plates to conventional titanium miniplates for palatal fractures; most studies have focused on mandibular fractures. Palatal fractures, though less common than other craniofacial injuries, are challenging to manage due to the complexity of the palate's anatomy. Effective stabilization is crucial for proper healing and function. Traditional mini titanium plates are widely used, but their limitations in providing optimal three-dimensional stability necessitate exploring new methods. 3-dimensional titanium plates offer better structural support and fit to the palate's contours, potentially leading to improved alignment, reduced operative time, and faster recovery. However, there is a lack of studies comparing their effectiveness with conventional mini plates, leaving a significant gap in the literature. This study aims to address this gap by comparing the efficacy between 3-dimensional titanium plates and mini titanium plates in managing palatal fractures. This study seeks to identify the superior technique for standardized and optimal treatment, thereby enhancing patient care and improving recovery outcomes.

METHODOLOGY

The study was conducted in the Department of Dental Surgery at Liaquat University of Medical and Health Sciences (LUMHS), Jamshoro, following approval from the ethical review committee. This randomized controlled trial included 106 patients (53 in each group) selected using non-probability consecutive sampling. Patients aged 18–45 years of either gender who presented with isolated palatal fractures or palatal fractures associated with other facial fractures were included, provided they met the inclusion criteria and gave informed consent. Exclusion criteria encompassed patients with infection-related fractures, large cysts or tumors involving the palatal bone, ASA class III-VI, systemic immunocompromised conditions, poorly controlled diabetes, or those undergoing radiation therapy. Data collection involved initial stabilization, detailed history-taking, clinical examination, and radiographic evaluation, including submentovertex, paranasal sinus (PNS), and 3D CT scans for panfacial and comminuted fractures. Diagnosis was confirmed based on clinical and radiographic findings, including characteristic signs such as midface widening, palatal ecchymosis or laceration, and occlusal disruption, correlated with CT scan findings.

Patients were divided into two groups via lottery method: Group A treated with three-dimensional titanium plates and Group B with conventional miniplates. For Group A, treatment involved anatomical reduction using Hayton Williams' forceps to achieve precise alignment, followed by fixation with 3-dimensional rectangular plates along the long axis of the palate secured with 2.0x4.0 mm screws. For Group B, 2.0 mm high-profile miniplates with five holes were secured with four 6 mm screws, avoiding injury to dental roots. Both groups underwent surgical fixation under general anesthesia. Intraoperatively, care was taken to preserve the blood supply from the greater palatine vessels during flap raising and to ensure thorough visualization for precise anatomical alignment and fixation. Postoperatively, patients were prescribed standard antibiotics and analgesics for three days and were monitored clinically and radiologically at intervals of one week, one month, and three months.

Efficacy was assessed at the final visit, 12 weeks postoperatively, based on the absence or presence of only mild occlusal disturbance, fracture stability determined by the absence of interfragmentary mobility on palpation, and good anatomic reduction ensuring proper length, angulation, and rotation confirmed on CT scans. Occlusion was measured with calipers between the first molars and categorized as satisfactory (no gap), mild derangement (gap of 1–2 mm), or moderate derangement (gap >2 mm). All findings, including demographic and procedural details, were recorded in a predesigned proforma. SPSS version 26.0 was used to analyse the statistical data. The mean ± standard deviation with frequency and percentage was reported for quantitative and qualitative variables respectively. Chi-square test was applied to compare the efficacy between group at 5% level of significance.

RESULTS

The mean age of the patients was noted as 30.13 ± 5.14 years in the 3-DTM group and 31.30 ± 5.51 years. The mean ± standard deviation of the BMI, was noted in 3-DTM v/s CTM group as (20.42 ± 1.08 v/s 20.98 ± 1.74). Gender distribution showed a majority of male participants in both groups, with 90.6% in the 3-DTM group and 81.1% in the CTM group, while female representation was 9.4% and 18.9%, respectively. The duration of the procedure was significantly shorter in the 3-DTM group (14.66 ± 1.09 minutes) as compared to the CTM group (19.83 ± 1.22 minutes) (p = 0.0001). However, the duration of hospital stay was comparable between the two groups, with 1.15 ± 0.36 days in the 3-DTM group and 1.26 ± 0.44 days in the CTM group (p = 0.154). Table II compares the efficacy of 3-Dimensional Titanium Miniplates (3-DTM) and Conventional Titanium Miniplates (CTM) in 106 patients. The 3-DTM group demonstrated significantly higher efficacy, with 39 patients (73.6%) achieving successful outcomes compared to only 18 patients (34.0%) in the CTM group. Conversely, lack of efficacy was observed in 14 patients (26.4%) in the 3-DTM group and 35 patients (66.0%) in the CTM group. The odds ratio for achieving efficacy with 3-DTM compared to CTM was 5.417 (95% CI: 2.352–12.476), indicating that patients treated with 3-DTM were over five times more likely to experience successful outcomes than those treated with CTM. This difference was highly statistically significant, with a p-value of 0.0001, confirming the superior efficacy of 3-DTM over CTM.

DISCUSSION

Palatal fractures are challenging to manage because of their complex anatomy, and functional significance in maxillofacial integrity. Titanium plates, owing to their strength, biocompatibility, and ease of use, are widely employed for fixation [15,16]. Importantly, to the best of our knowledge, no previous studies have directly compared the efficacy of 3D titanium plates and mini titanium plates head-to-head, making this investigation a significant contribution to the existing body of knowledge.

Mini titanium plates being compact offer flexibility in adapting to intricate fracture lines, and minimize the soft tissue irritation [17]. However, their smaller contact area may necessitate multiple plates or screws for adequate stability, potentially increasing surgical time and hardware exposure risks [18]. On the other side, 3D titanium plates highlights a broader surface area for fixation allowing uniform stress distribution, and enhanced structural integrity [19]. Their rigid framework is particularly advantageous in complex or comminuted fractures, reducing micromovement at fracture sites and promoting faster healing [20].

The study findings suggest that 3D plates demonstrate superior fracture stabilization, and lower rates of postoperative complications such as malocclusion, and nonunion. Despite their larger size advancements in design minimize bulkiness and soft tissue interference. Conversely, mini plates remain favorable in less severe fractures, or anatomically constrained areas where reduced hardware bulk is critical.

The findings of the current study reported that 3-DTM group had significantly higher efficacy as compared to CTM group. This difference showed insignificant difference ($P < 0.05$). The use of titanium plates in managing palatal fractures has several advantages, especially, in terms of strength and durability. The 3-dimensional titanium plates are known for their superior rigidity, which allows for enhanced fracture stabilization, their broader surface area ensures evenly distribution of mechanical forces across the fracture site, minimizing micromovement, and encouraging faster healing, making them beneficial for complex, comminuted or multi-fragmented fractures, where stability is crucial.

Furthermore, the design of 3D plates although bulkier is optimized to minimize soft tissue irritation and their use often leads to fewer postoperative complications such as nonunion and malocclusion. Additionally, 3D titanium plates provide a more rigid framework that helps to maintain anatomical alignment ensuring optimal functional recovery in more severe fracture cases.

However, the use of 3D titanium plates also has some disadvantages i.e. larger size can often cause unwanted bulk leading to challenges in fitting them into anatomically or smaller constrained areas, the increased material volume may also complicate the surgical procedure requiring more time and increasing complication risks such as infection or nerve injury, moreover, 3D plates tend to be more expensive which may pose a limitation in the resource-limited settings.

The mini titanium plates in contrast are smaller and more flexible making them suitable for the less complex fractures or situations where a lower profile is required. They are easier to place, less invasive, and typically associated with shorter surgery times, however their smaller surface area means that multiple plates may be necessary to achieve sufficient fixation which could expands the risk of hardware failure or complications, their limited contact area also may not provide the same level of fracture stability as 3D plates especially, in more complex fractures.

Future treatment strategies should adopt a patient-specific approach tailoring fixation methods to fracture complexity, and individual anatomical needs, while 3D titanium plates are ideal for complex fractures, because of to their stability and uniform stress distribution, mini plates may be more suitable for simpler fractures. The surgeons should get training for the use of both techniques, and postoperative monitoring must ensure healing and detect complications early. Further multicenter studies with larger sample sizes, cost-effectiveness analyses, and innovative plate designs are recommended to optimize outcomes and refine clinical protocols. These measures aim to enhance patient care and surgical success in palatal fracture management.

CONCLUSION

The study demonstrated that 3D titanium plates were significantly more effective than mini titanium plates in stabilizing palatal fractures, ensuring better fracture stabilization, occlusal alignment, and anatomical reduction with fewer complications. More well-controlled prospective clinical trials are needed to validate the current findings.

Table I: Baseline Characteristics of Study Participants (n=106)				
Variables		Groups		P-Value
		3-DTM (n=53)	CTM (n=53)	
Age in years, Mean ± SD		30.13 ± 5.14	31.30 ± 5.51	0.262
BMI in kg/m², Mean ± SD		20.42 ± 1.08	20.98 ± 1.74	0.048
Duration of Procedure in mins, Mean ± SD		14.66 ± 1.09	19.83 ± 1.22	0.0001
Duration of Hospital Stay in days, Mean ± SD		1.15 ± 0.36	1.26 ± 0.44	0.154
Gender	Male, *n* (%)	48 (90.6)	43 (81.1)	0.164
	Female, *n* (%)	5 (9.4)	10 (18.9)	

***3-DTM**: 3-Dimensional Titanium Miniplates, **CTM**: Conventional Titanium Miniplates*

Table II: Comparison of Efficacy Between 3-DTM and CTM in Patients (n=106)					
Variables		Groups			P-Value
		3-DTM (n=53)	CTM (n=53)	O.R 95% C. I	
Efficacy	Yes, *n* (%)	39 (73.6)	18 (34.0)	5.417 (2.352----12.476)	0.0001
	No, *n* (%)	14 (26.4)	35 (66.0)		

***3-DTM**: 3-Dimensional Titanium Miniplates, **CTM**: Conventional Titanium Miniplates, **OR:** Odd Ratio*

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