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Comparison of 3-D Locking Miniplates Versus Conventional Miniplates in Anterior Mandibular Fractures

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Abstract:-
Background: Throughout history, humans have grappled with painful injuries, prompting a relentless quest for effective treatments. The origins of early attempts at self-healing, such as the first instances of adjusting fractures or dislocations, remain uncertain. It is conceivable that in the early Stone Age, fractured limbs were supported by splints crafted from wood or bamboo, embedded in clay and allowed to harden.

In our modern age of increased motorization, industrialization, and technological advancements, the management of maxillofacial injuries has assumed a significant role. The prevalence of road traffic accidents, on the rise in today's world, has notably contributed to the surge in maxillofacial injuries. The head, being the most exposed part of the body, bears the brunt of injuries, constituting the highest percentage among all body regions. Other contributors to maxillofacial injuries include interpersonal violence, falls, sporting mishaps, and industrial trauma. Neglect or inadequate treatment of fractures can lead to enduring consequences, encompassing functional, aesthetic, neurological, and psychological impairments.[1]

Materials and methods: The research was conducted with the approval of the institutional ethical committee, spanning a two-year period during which a thorough evaluation was performed on a cohort of 20 subjects.

Results: The utilization of 3D titanium locking plates presents a viable alternative to conventional miniplates due to their enhanced stability resulting from a sophisticated screw locking mechanism, thereby providing superior stability.

I. INTRODUCTION

While the term "fracture" is complex to define, a simplified explanation characterizes it as a disruption in the continuity of bone, resulting from stress beyond its elastic modulus and leading to the formation of two or more fragments. The primary objective in treating bone fractures is to reliably restore their pre-injury anatomical form, encompassing both aesthetics and function.

Over the past decades, the approaches to managing mandibular fractures have undergone significant evolution. These techniques have spanned from closed reduction with maxillo-mandibular fixation (MMF) to open reduction with wire osteosynthesis, and further to open reduction with either rigid internal fixation or adaptive miniplate fixation. [2]

Prolonged use of Maxillo-Mandibular fixation [MMF] earlier known as Intermaxillary Fixation [IMF], for treating mandibular fractures has had certain disadvantage of not being able to attain absolute reduction and stability, noncompliance of patients, difficulty in nutrition as well as maintaining oral hygiene along with weight loss. It also had effects like muscular dystrophy, secondary changes in temporomandibular joint and compromised airway up to 40%. [3]

The concept of open reduction and internal fixation (ORIF) for mandibular fractures using bone plates was initially introduced by Schede in 1888, employing steel plates and screws. The implementation of rigid fixation, particularly with compression plates, has significantly reduced the duration of Maxillo-Mandibular Fixation (MMF) and facilitated an early restoration of mandibular function.[4]

Over the decades, a range of plate and screw osteosynthesis methods has emerged, such as the AO bicortical plating system, two-dimensional Mini plating system, resorbable plates and screws, 3-dimensional Mini plating system, and locking miniplate system. Ongoing research is dedicated to optimizing the surgical outcome by exploring factors like the size, shape, number, and biomechanics of plate/screw/system configurations.

Miniplate osteosynthesis, initially introduced by Michelet in 1973 and further refined by Champy in 1976, stands as the contemporary standard for treating mandibular fractures. Champy elucidated the optimal lines of osteosynthesis, specifying where plates should be applied to effectively counteract torsional forces. The technique's key advantages lie in circumventing the drawbacks associated with intermaxillary fixation.[4]

One drawback associated with conventional bone plate and screw systems is the necessity for the plate to be meticulously and precisely adapted to the underlying bone. This precision is essential to prevent any deviations in the alignment of bone segments and alterations in the occlusal relationship.[1]The stability of a conventional bone plating system relies on the compression of the fixation plate to the bone by the screw head as it is tightened. Miniplates placed trans-orally, following the method described by Champy, have gained widespread acceptance for mandibular fracture treatment. More recently, 3-Dimensional plates and screws, designed for "semi-rigid" fixation, have been developed to provide stability with fewer complications. Their geometric shape is based on the quadrangle principle, offering a stable

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configuration for support, as opposed to conventional plates, where 3D stability is achieved through the geometric shape forming a cuboid.

The newly introduced 3D-locking plating system offers distinct advantages over conventional miniplates. This system utilizes fewer plates and screws compared to traditional miniplates to stabilize bone fragments. In conventional miniplates, two plates are typically recommended in the Para symphysis region, while only one 3-D plate is necessary for the same purpose. This not only reduces the amount of foreign material used but also decreases operation time and overall treatment costs.

Locking systems provide ease of plate adaptation and enhanced stability without exerting excessive pressure on the underlying bone. Essentially functioning as internal fixators, these plates achieve stability by securely locking the screw to the plate.[3]

II. MATERIALS AND METHODS

The current study was conducted at the Department of Oral & Maxillofacial Surgery, Shree Bankey Bihari Dental College and Research Centre, Masuri, Ghaziabad. The research included 20 patients with isolated anterior mandibular fractures, excluding those with pre-existing infection and comminution. The participants were randomly divided into two groups, each consisting of 10 patients. In Group 1, patients underwent osteosynthesis utilizing 2.0mm Conventional miniplates, while in Group 2, patients underwent osteosynthesis employing 2.0mm 3D Locking miniplates.

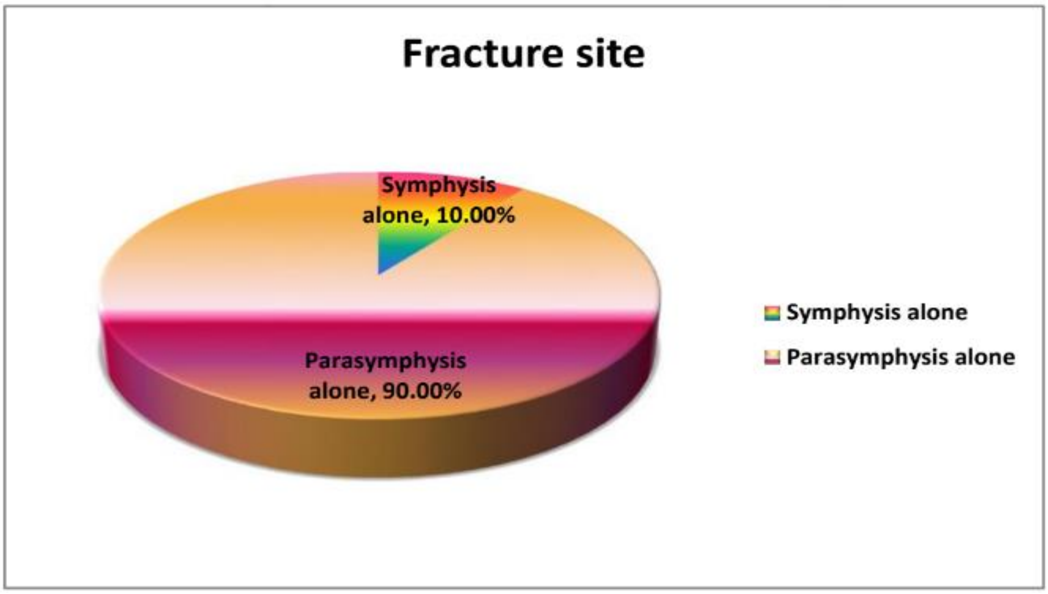
III. RESULTS

The conducted study took place at the Department of Oral & Maxillofacial Surgery, Shree Bankey Bihari Dental College and Research Centre in Masuri, Ghaziabad. A total of 20 patients with isolated anterior mandibular fractures, devoid of pre-existing infection and comminution, were carefully chosen. The patients were then randomly assigned to two groups, each consisting of 10 individuals. Group 1 patients underwent osteosynthesis using 2.0mm Conventional miniplates, while Group 2 patients underwent osteosynthesis utilizing 2.0mm 3D Locking miniplates.

The most prevalent cause of injury in the study was road traffic accidents, accounting for 60% of cases, followed by falls from height at 20%, assaults at 10%, and other etiologies making up the remaining 10%.

Table 1: Site-wise distribution

Fracture site	Number of patients with fractures	Percentage of patients with fractures
Symphysis alone	2	10.0%
Parasymphysis alone	18	90.0%



Graph 1: Site-wise distribution

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Para symphysis alone was the commonest site of fracture (90%). Symphysis alone was the least common site of fracture (10%).

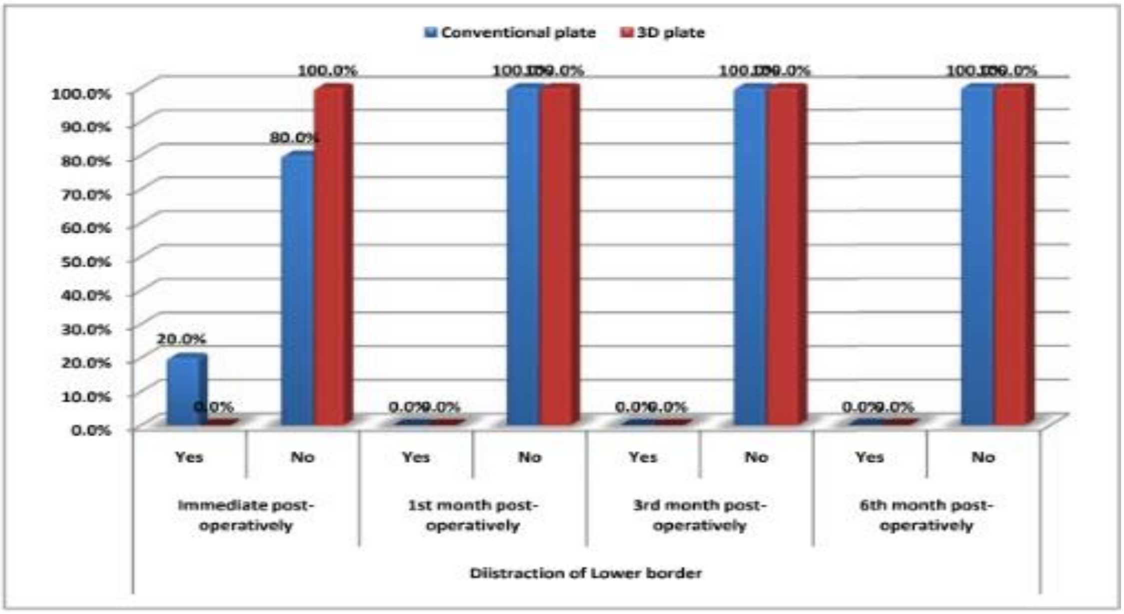
IV. CLINICAL EVALUATION

The comparison of lower border distraction between Conventional plates and 3D plates was conducted at four different time points: immediately post-operatively, 1st month post-operatively, 3rd month post-operatively, and 6th month post-operatively, utilizing the Chi-square test. The analysis revealed no significant difference in lower border distraction between Conventional plates and 3D plates at the 1st, 3rd, and 6th months post-operatively. However, it's noteworthy that the distraction of the lower border was significantly greater among patients with Conventional plates immediately post-operatively.

Table 2: Difference in lower border distraction between conventional plates and 3D plates

Distraction of Lower border		Conventional plate	3D plate	Chi-square value	p-value
Immediate post-operatively	Yes	2	0	3.569	0.049*
		20.0%	0.0%		
	No	8	10		
		80.0%	100.0%		
1st month post-operatively	Yes	0	0	0.000	1.000#
		0.0%	0.0%		
	No	10	10		
		100.0%	100.0%		
3rd month post-operatively	Yes	0	0	0.000	1.000#
		0.0%	0.0%		
	No	10	10		
		100.0%	100.0%		
6th month post-operatively	Yes	0	0	0.000	1.000#
		0.0%	0.0%		
	No	10	10		
		100.0%	100.0%		

Chi-square test * Significant difference # Non-significant diff



Graph 2: Difference in lower border distraction between conventional plates and 3D plates

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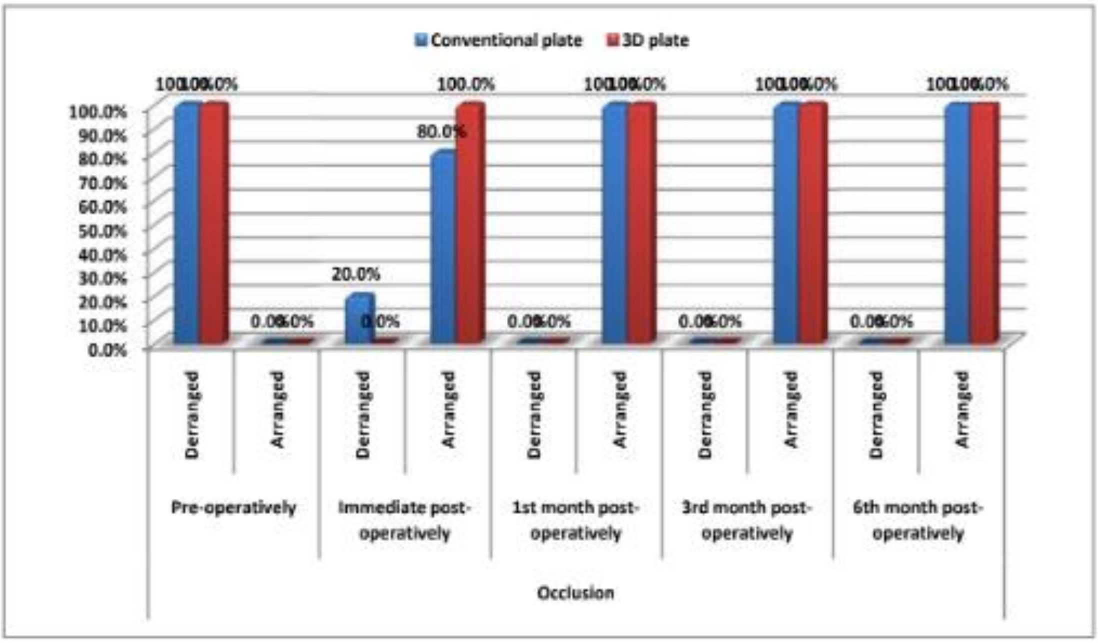
The distribution of occlusion was thoroughly compared between Conventional plates and 3D plates at various time points: pre-operatively, immediately post-operatively, 1st month post-operatively, 3rd month post-operatively, and 6th month post-operatively, employing the Chi-square test. The statistical analysis revealed no significant difference in the distribution of occlusion between Conventional plates and 3D plates at any of the specified time points, including pre-operatively, immediately post-operatively, 1st month post-operatively, 3rd month post-operatively, and 6th month post-operatively.

Table 3: Distribution of occlusion compared between Conventional plates and 3D plates

Occlusion		Conventional plate	3D plate	Chi-square value	p-value
Pre-operatively	Deranged	10	10	0.000	1.000#
		100.0%	100.0%		
	Arranged	0	0		
		0.0%	0.0%		
Immediate post-operatively	Deranged	2	0	0.000	1.000#
		20.0%	0.0%		
	Arranged	8	10		
		80.0%	100.0%		
1st month post-operatively	Deranged	0	0	0.000	1.000#
		0.0%	0.0%		
	Arranged	10	10		
		100.0%	100.0%		
3rd month post-operatively	Deranged	0	0	1.053	0.305#
		0.0%	0.0%		
	Arranged	10	10		
		100.0%	100.0%		
6th month post-operatively	Deranged	0	0	1.053	0.305#
		0.0%	0.0%		
	Arranged	10	10		
		100.0%	100.0%		

Chi-square test # **Non-significant difference**

Graph 3: Distribution of occlusion compared between Conventional plates and 3D plates

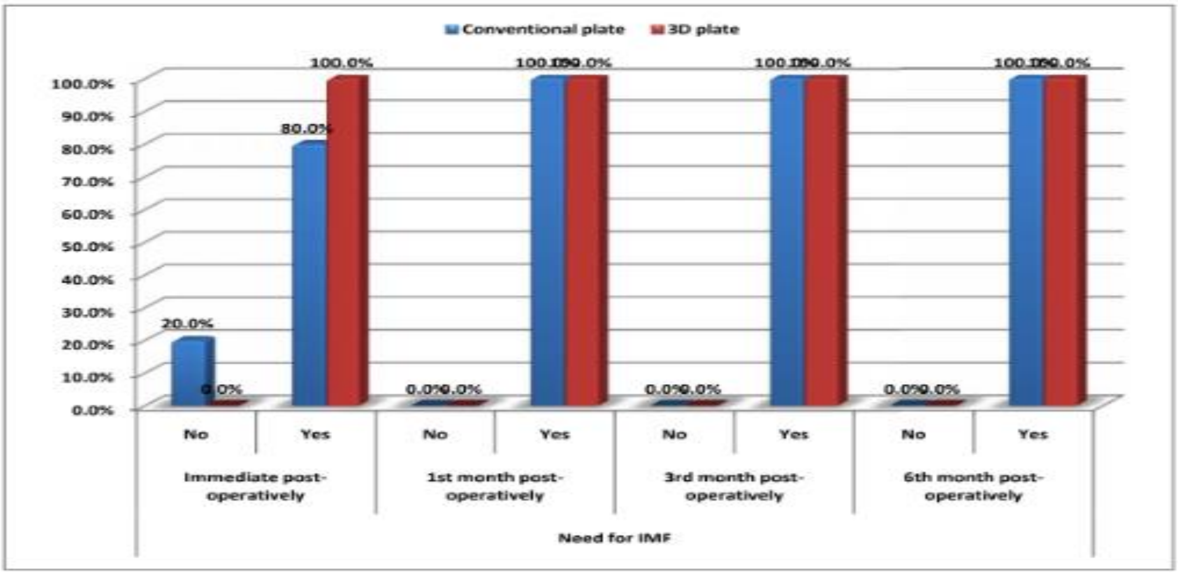


The distribution of Need for IMF was compared between Conventional plate and 3D plate. Immediate post-operatively, 1st month post-operatively, 3rd month post-operatively and 6th month post-operatively using the Chi-square test. There was no significant difference in the distribution of Need for IMF between Conventional plate and 3D plate 3rd month post- operatively and 6th month post-operatively. There were significantly a greater number of cases of Need for IMF among Conventional plate Immediately post-operatively.

Table 4: Distribution of Need for IMF compared between Conventional plate and 3D plate

Need for IMF		Conventional plate	3D plate	Chi-square value	p-value
Immediate post-operatively	No	8	10	3.333	0.048*
		80.0%	100.0%		
	Yes	2	0		
		20.0%	0.0%		
1st month post-operatively	No	10	10	0.000	1.000#
		100.0%	100.0%		
	Yes	0	0		
		0.0%	0.0%		
3rd month post-operatively	No	10	10	0.000	1.000#
		100.0%	100.0%		
	Yes	0	0		
		0.0%	0.0%		
6th month post-operatively	No	10	10	0.000	1.000#
		100.0%	100.0%		
	Yes	0	0		
		0.0%	0.0%		

Chi-square test # **Non-significant difference**



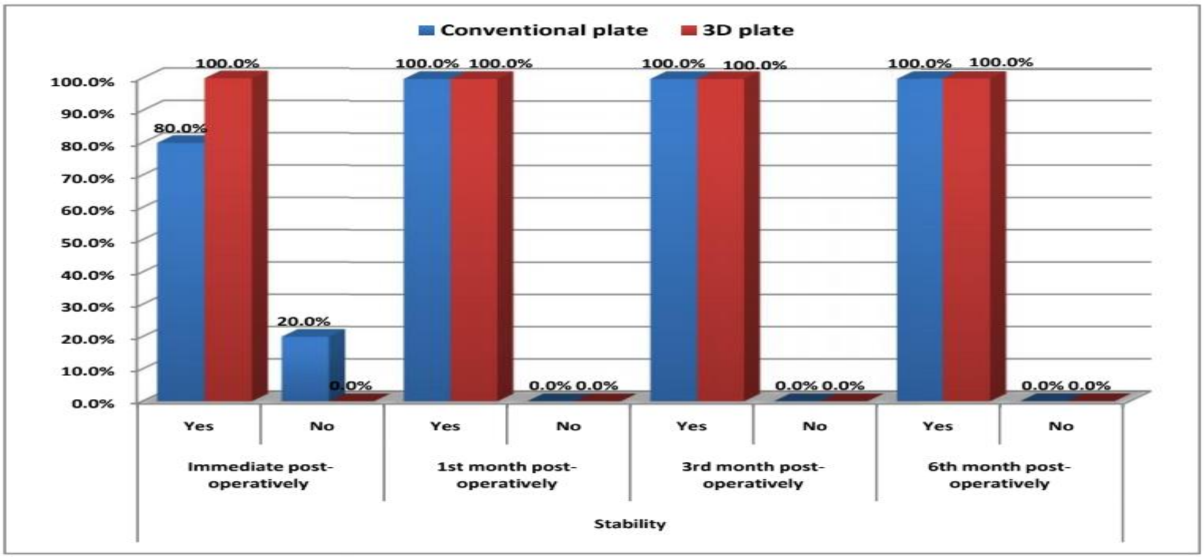
Graph 4: Distribution of Need for IMF compared between Conventional plate and 3D plate

The distribution of stability was systematically compared between Conventional plates and 3D plates at different intervals: immediately post-operatively, 1st month post-operatively, 3rd month post-operatively, and 6th month post-operatively, utilizing the Chi-square test. The analysis indicated no significant difference in the distribution of stability between Conventional plates and 3D plates at any of the specified time points, including immediately post-operatively, 1st month post-operatively, 3rd month post-operatively, and 6th month post-operatively.

Table 5: Distribution of stability systematically compared between Conventional plates and 3D plates

Stability		Conventional plate	3D plate	Total	Chi-square value	p-value
Immediate post-operatively	Yes	8	10	18	0.556	0.456#
		80.0%	100.0%	90.0%		
	No	2	0	2		
		20.0%	0.0%	20.0%		
1st month post-operatively	Yes	10	10	20	0.000	1.000#
		100.0%	100.0%	100.0%		
	No	0	0	0		
		0.0%	0.0%	0.0%		
3rd month post-operatively	Yes	10	10	20	0.000	1.000#
		100.0%	100.0%	100.0%		
	No	0	0	0		
		0.0%	0.0%	0.0%		
6th month post-operatively	Yes	10	10	20	0.000	1.000#
		100.0%	100.0%	100.0%		
	No	0	0	0		
		0.0%	0.0%	0.0%		

Chi-square test **#Non-significant difference**



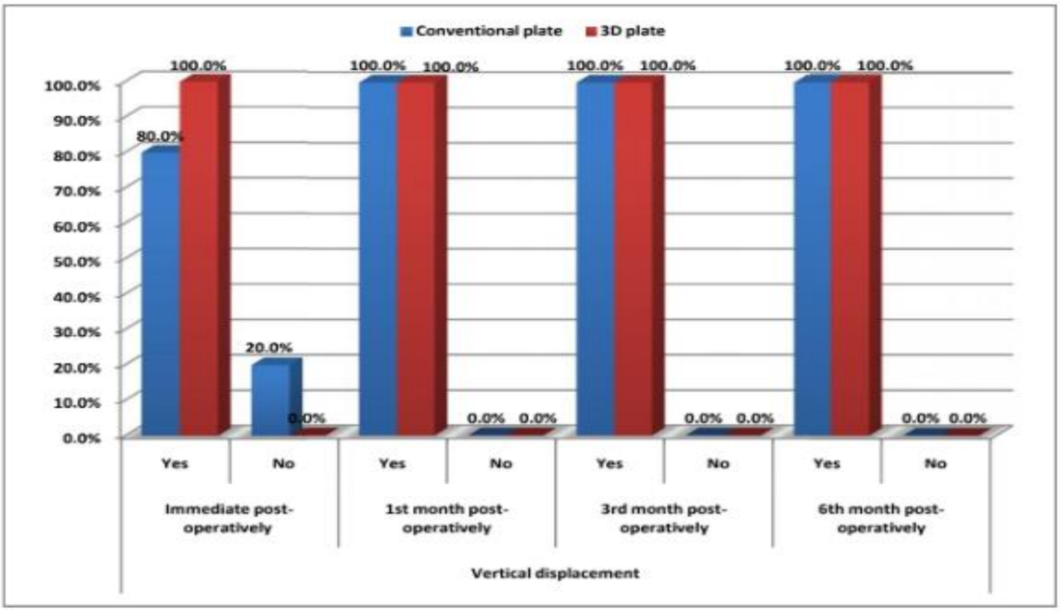
Graph 5: Distribution of stability systematically compared between Conventional plates and 3D plates

The distribution of vertical displacement was examined and compared between Conventional plates and 3D plates at various time points: immediately post-operatively, 1st month post-operatively, 3rd month post-operatively, and 6th month post-operatively, using the Chi-square test. The results revealed no significant difference in the distribution of vertical displacement between Conventional plates and 3D plates at any of the specified time points, including immediately post-operatively, 1st month post-operatively, 3rd month post-operatively, and 6th month post-operatively.

Table 6: Distribution of vertical displacement examined and compared between Conventional plates and 3D plates

Vertical displacement		Conventional plate	3D plate	Chi-square value	p-value
Immediate post-operatively	No	2	0	0.556	0.456#
		20.0%	0.0%		
	Yes	8	10		
		80.0%	100.0%		
1st month post-operatively	No	0	0	0.000	1.000#
		0.0%	0.0%		
	Yes	10	10		
		100.0%	100.0%		
3rd month post-operatively	No	0	0	0.000	1.000#
		0.0%	0.0%		
	Yes	10	10		
		100.0%	100.0%		
6th month post-operatively	No	0	0	0.000	1.000#
		0.0%	0.0%		
	Yes	10	10		
		100.0%	100.0%		

Chi-square test **#Non-significant difference**



Graph 6: Distribution of vertical displacement examined and compared between Conventional plates and 3D plates

V. DISCUSSION

Mandible is the second most commonly fractured bone of the maxillofacial skeleton and 10th most commonly fractured bone in the whole body. It is a horse shoe-shaped bone occupying a very prominent and vulnerable position on the face.[5] Given its strategic position and prominence, the mandible plays a crucial role in ensuring the survival of an individual. It serves as a vital structure for protecting the airway, facilitating the proper function of the stomatognathic system, and possessing the unique ability to disperse externally applied forces in a manner that helps prevent fatal brain injuries.[6]

The benefits of Rigid Internal Fixation (RIF) have been extensively highlighted in reviews by various authors. Primary advantages include the promotion of primary bone healing without the prolonged necessity of intermaxillary fixation for immobilization,[7] hence rapid return to normal masticatory function and mouth opening, minimal disturbances to body weight, less time lost from employment, and early mobilization.[8]

A total of 20 patients diagnosed with isolated anterior mandibular fractures, without pre-existing infection and comminution, were carefully chosen for this study. These patients were randomly assigned into two equal groups, each consisting of 10 individuals. Group 1 patients underwent osteosynthesis using 2.0 mm conventional miniplates, while Group 2 patients underwent osteosynthesis with 2.0 mm 3D locking miniplates.

In the symphysis and parasymphysis region, the 3D locking plating system demonstrated advantages, specifically in reducing operation time and the overall cost of treatment. However, it's important to note that in other areas of the mandible, the hardware used remains the same with comparable costs for both systems.

Thus, 3D locking plate can be used as an alternative to conventional miniplates. The system is reliable and effective treatment modality for mandibular fractures as the traditional miniplates. Further, the use of 3D locking plating system in various procedures of maxillofacial region needs to be explored.

VI. CONCLUSION

The primary objective of this study was to compare the effectiveness of 3D titanium locking miniplates with conventional miniplates in the treatment of mandibular fractures. Based on our findings, the following conclusions were drawn:

- Road traffic accidents were identified as the most common cause of mandibular fractures, accounting for 60% of cases.
- The age group most frequently presenting with mandibular fractures was 21-30 years, comprising 55% of patients.
- Males were predominantly affected by mandibular fractures, constituting 80% of the cases.
- The para symphysis was the most common site of fracture (90%), followed by the symphysis (10%).
- Initial follow-ups revealed instances of distraction of the lower border, minimal occlusal discrepancies, and slight mobility, particularly in 20% of patients in Group 1. This was managed with intermaxillary fixation (IMF) for four weeks.
- Infection occurred in only 10% of patients in Group 1 at the 3rd month follow-up, attributed to screw loosening. This was successfully treated with implant removal and antibiotics.

In summary, our study indicates that 3D titanium locking miniplates are effective in treating mandibular fractures, with lower overall complication rates compared to conventional miniplates. Both systems provide adequate stability after fracture fixation. The stability of 3D titanium locking plates is achieved through their configuration, not just thickness or length, utilizing a defined surface area. The system's large free areas between plate arms and minimal dissection allow for good blood supply to the bone. The 3D titanium locking miniplates are user-friendly, more stable, and require less hardware for fixation. Therefore, they can serve as a reliable and effective alternative to conventional miniplates in the treatment of mandibular fractures. These findings underscore the efficacy of locking plates in bearing masticatory loads during fracture osteosynthesis, providing greater stability with clinical results comparable to non-locking plate osteosynthesis.

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