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Original Research

Comparative evaluation of 3-dimensional conventional versus 3dimensional locking titanium miniplates in treatment of mandibular fractures- a clinical study

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ABSTRACT:

Purpose: The aim of this follow up clinical study was to compare and evaluate the effectiveness of 3-dimensional (3D) locking titanium miniplates over 3-dimensional conventional plate fixation in the management of mandibular fractures. **Patients and methods:** A clinical trial was carried out in patientswith well defined inclusion and exclusion criteria. Patients were followed for a period of 3 months at theintervals of 1st day,3rd day,1 week, 2 weeks, 4 weeks, 1 month and 3 months for pain, swelling, wound dehiscence, significant postoperative complications, segmental mobility, radiological evaluation with respect to reduction and healing of fracture and the need for postoperative Inter-Maxillary Fixation (IMF). Duration of surgery was also noted and compared. **Result:** 10 patients were enrolled in both the groups. 3D locking plates showed promising result in adaptability, required less operating time, and provided better stability. **Conclusion:** 3-dimensional locking plate system provides an effective option for the treatment of mandibular fractures as compared to 3-dimensional locking plate system because of their potential advantages like reduced time for fixation, easy handling, manipulation and lesser need for precise adaptation.

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INTRODUCTION

Three-dimensional titanium plates and screws were developed and reported byFarmand and Dupoirieux (1992). Their shape is based on the principle of the quadrangle as a geometrically stable configuration for support because three-dimensional stability is achieved by the geometric shape that forms a cuboid.¹ This quadrangular design formed by joining two miniplates with interconnecting crossbars allows easy adaptation of plate to the bone without any distortion. The free area between these connecting arms permits good blood supply to the bone. This mechanical property makes them suitable for use in symphyseal fractures, which are under a greater degree of torsional strain and limited vascularity.²

3 dimensional miniplates are difficult to adapt as a geometric plate is much broader and has to be bent in 3 dimensions whereas a linear plate has only to be bent in 2 dimensions. A geometric plate is much harder to perfectly adapt than a linear plate because it is trying to adapt a "plane" rather than a "line" to a curved surface. A locking system is incorporated in a plate design to obviate the need for precise adaptation to intimately contact the underlying bone in all areas which is mandatory in the case of standard and 3D miniplates.³

Another advantage to the use of locking bone plate– screw systems is that the screws are unlikely to loosen from the bone. This means that even if a screw is inserted into a fracture gap, loosening of the screw will not occur. The possible advantage to this property of a locking plate–screw system is a decreased incidence of inflammatory complications from loosening of the hardware. For the hardware or a locking plate–screw system to loosen, loosening of a screw from the plate or loosening of all of the screws from their bony insertions would have to occur. Both of these are unlikely. Added advantage to a locking screw–plate system is that the amount of stability provided across the fracture gap is greater than when standard non-locking screws are used.^{4,5,6}

Thus, locking system allows easy bending of plate and obviates the need for precise adaptation.⁷It exhibits stress sharing property as there is less disturbance of perfusion of underlying bone with decreased bone necrosis, which might lead to better bone healing and regeneration. So, locking system increases primary stability which leads to greater stability across the fracture site.⁸There is lesser alteration in osseous or occlusal relationship upon screw tightening. There is no need for a friction lock between plate and bone for stability which results in decreased pressure transmitted to underlying bone.⁹

Therefore, a locking system was added to 3-Dimensional conventional titanium miniplates so that 3D locking plates have advantages of both the systems.Keeping all these aspects in mind, the present study was carried out in the Department of Oral and Maxillofacial Surgery to compare and evaluate the workability of the 3-Dimensional conventional and 3dimensional locking titanium miniplates in the treatment of mandibular fractures.

MATERIAL AND METHODS

Twenty adult patients reporting to the Department of Oral and Maxillofacial Surgery for the treatment of mandibular fractures were included in the present study. All the patients were screened for the suitability of the treatment, irrespective of age, sex, caste, religion and socio-economic status.

Any fracture of mandible involving symphysis, parasymphysis, body, angle region or combination of the above indicated for open reduction with internal fixation (ORIF) were included.Patients who did not give consent for surgery, contraindications for the surgery due to systemic conditions, neurosurgical involvement where consent for surgery was not given by the neurosurgeon and who did not comply with regular follow up were excluded.

A relevant history of all patients was taken, local and general physical examination was conducted in every case. Diagnosis of the fracture mandible was made on the basis of history, clinical and radiological examination. Routine laboratory investigations were done to rule out any possibility of systemic conditions in the selected cases. Selection of cases for the 3D conventional as well as 3D locking plates was done on odd-even basis.

The surgery was carried out either under local or general anaesthesia. Maintaining the general aseptic protocol, the fracture site was exposed intraorally or extraorally as indicated. Fracture site was manipulated and reduced manually, and then the occlusion was achieved with the help of Maxillo-Mandibular Fixation.Internal fixation of fracture was done with the help of 3-D conventional/locking titanium miniplates of appropriate length and design depending on the fracture configuration. The miniplate was positioned so that the horizontal cross-bars were perpendicular to the fracture line and the vertical ones were parallel to it. In the symphysis and parasymphysis region, the upper bar was placed in a sub apical position to the roots of anterior teeth. Posterior to the mental foramen, the plates were placed with the superior bar between the roots and the inferior alveolar nerve and the lower bar below the nerve. To treat fractures near the mental foramen, the lower bar of the plate was bent and placed above the mental nerve. In fractures incorporating the mental foramen, vertical strut of the plate was cut and followed by placement of plate around the mental foramen. In the mandibular angle region, the plate was bent over the oblique line so that the vertical bars were aligned perpendicular to the external oblique ridge.

The 3-D plates were bent with the help of bone plate bending pliers according to the contour of the underlying bone. Twist drill was used to drill holes through the plates into the bone under copious normal saline irrigation. Monocortical screws of appropriate length were used to fix the plate to the fractured bony fragments. In case of locking plates, fixation by 3D locking plates and monocortical screws was performed using a drill bit and drill guide.

IMF was released and occlusion was checked. Layer wise closure was done after proper irrigation with mild antibiotic solution. The duration of procedure from starting of incision placement to wound closure was noted.

Any swelling, if present was noted at the postoperative periods.Segmental mobility was noted at all follow-up periods by a single observer and thus, the need for post-operative Inter-maxillary fixation was evaluated.On radiological evaluation, the osteogenic changes (osteogenesis and union) were seen with the help of OPG at 3 months follow-up which was compared with the pre-operative OPG by a single observer. Patients were followed for a minimum period of 3 months at an interval of 1st day, 3rd day, 1 week, 2weeks, 1 month and 3 months. Various parameters were recorded and results were compared evaluated.Significant and post-operative complications and wound dehiscence were noted at each follow-up period by a single observer.

RESULTS

Amongst the twenty cases which were included for the study for the treatment of mandibular fractures at the Department of Oral and Maxillofacial Surgery, the most common cause of injury was road traffic accident (70%), fall (20%) and assaults (10%). The mean duration of surgery with 3-D locking plate was 40.7 minutes and with 3-D conventional plate was 52.3 minutes. The p-value comes out to be 0.001 which shows the result is statistically significant.Postoperative pain was evaluated at 1st post-op day, 3rd day, 1 week, 2 weeks, 1month and 3 months. The pvalues at all follow-up periods came out to be >0.05. This shows that the results were insignificant.Swelling was present in all the patients at 1st post-operative day, 3rd post-operative day and then gradually reduced up to one week. After two weeks, swelling was present in one of the patients with 3D locking plate and two of the patients with 3D conventional plate. No swelling was present at one month and three months in both the groups. Wound dehiscence was noted in one patient in group A on 3rd post-operative day and Group B on 1st post-operative day. It was present till one week in both cases and then resolved subsequently. Both the groups did not show any significant post-operative complications like bone plate palpability, neurosensory deficit, malunion, nonunion,etc.

None of thepatients showed segmental mobility in both groups.All the patients in both groups A and B showed favourableosteogenic changes thus giving satisfactory results on radiological evaluation.None of thepatients required post-operative IMF in both Group-A (3D Locking) and Group-B (3D conventional plate).



FIG SHOWING DRILL BIT, DRILL GUIDE, 3-D LOCKING PLATE AND SCREWS



FIG SHOWING 3-D CONVENTIONAL PLATE AND SCREWS



FIG SHOWING USE OF DRILL GUIDE FOR 3-D LOCKING PLATE

DISCUSSION

According to the available literature, few clinical trials have compared the efficacy of 3-D locking plate systems with 3-D conventional plate systems in the treatment of mandibular fractures. This study was designed with an aim of evaluating and comparing the efficacy of 3D conventional and 3D locking titanium miniplates in the mandibular fractures. The study consisted of twenty patients which were divided into two groups- Group-A which were managed using 3D locking titanium miniplates and Group B treated using 3D conventional titanium miniplates.

Considering the etiology of the mandibular fractures, road traffic accidents (RTA) was the cause of mandibular fractures in 14(70%) cases, fall in 4 (20%) cases and in 2(10%) cases, it was interpersonal violence. This distribution compared favourably with the road traffic accidents being the main cause as shown in many studies.^{10,11, 12}

The patients in our study were evaluated at 1st day, 3rd day, 1st week, 2nd weeks, 1 month, and 3 months postoperatively. The parameters evaluated were – pain, swelling, wound dehiscence, segmental mobility, significant post-operative complications, radiological evaluation and need for post-operative Inter-maxillary fixation. The duration of surgery was also noted in all the cases and compared. All the values were analysed statistically.

In our study, mean duration of the surgery for group A (3D locking titanium miniplates) was 40.7 minutes and for group B (3D conventional titanium miniplates) was 52.3 minutes. The p-value comes out to be 0.001 which shows the result is statistically significant.In another similar study carried out by Dhananjay H Barde et al (2014), the average operating time required for 3-D plate was found to be 50.60min.¹³A similar study comparing the duration of surgery for 3-D locking titanium miniplate with standard miniplates was 17 and 38 minutes respectively.14This shows that the 3-D locking titanium miniplates required less time for placement and were easier to handle as precise adaptation of 3-D locking plates is not required and does not affect their mechanical behaviour.15,16,17

Also, 3-D locking miniplates show more stability as they resist torque forces as compared to 3-D conventional plate and exhibits stress sharing property as the screws are tightened, they "lock" to the plate, thus stabilising the segments without the need to compress the plate to the bone. There is less disturbance of perfusion of underlying bone with decreased bone necrosis, which lead to better bone healing and regeneration.^{1,18,19}

In the present study, all the patients in both groups did not require post-operative Inter-maxillary fixation. All had satisfactory postoperative occlusion without requiring any significant intervention. There is no need for postoperative Inter-maxillary fixation as advocated in other studies.^{14,20,21,22,23,24}

No significant postoperative complications like plate palpability, malunion or non-union were seen in both Group-A (3D locking plate) & Group-B (3D conventional plate) as the immediate postoperative complications are lesser due to smaller incision size, decreased tissue manipulation and greater stability.^{14,18,19}

Pain was seen in all the patients on 1^{st} post-operative day which gradually decreased till 3^{rd} post-operative day and completely resolved after one week in both the groups. The p-values at all follow-up periods came out to be >0.05 which showed that the results were insignificant.

In the present study, the swelling was present in all the patients at 1st post-operative day, 3rd postoperative day and then gradually reduced up to one week in both the groups. After two weeks, swelling was present in one of the patients in Group-A (3D locking plate) and two of the patients in Group-B (3D conventional plate). No swelling was present at one month and three months in both the groups.

Wound dehiscence was noted in one patient in group A from 3rd post-operative day & Group B from 1st post-operative day. It was present till one week in both cases and then subsequently resolved by local measures only.Thus, wound dehiscence comes out to be 10% in both groups. Wound dehiscence has been reported as 0% according to a study by Jain et al using 3-D locking plates¹⁴ and 6.6% by Parmaret al¹² and 2.7% by Guimondet al⁸ using 3-D plates.The sample size of our study was smaller. Therefore, wound dehiscence in this present study was considerably lower. However, it resolved satisfactorily in both groups.

Postoperative segmental mobility was not evident in any of our cases, similar to a study by SadhasivamGokkulakrishnan et al(2012) and Manoj Jain et al(2012).^{14,25}

In the present study, no case of delayed and non-union was found. Radiographically on evaluation, the osteogenic change (osteogenesis and union) was seen which showed that the healing was satisfactory during the follow-up period of 3 months. The results were similar to the study by Kawai T et al (1997).²⁶

Thus, this study has shown advantages like reduced time for fixation, ease of handling, manipulation and lesser need of precise adaptation for 3D locking plates in comparison to 3-D conventional miniplates. Limitations of the present study include small sample size and short follow-up time period. With the advantages of 3-D locking titanium locking plates shown in this present study and other known advantages of 3-D locking titanium locking plates such as stress sharing property, resistance to torque forces and increased stability, these bone plates can thus be recommended for the management of mandibular fractures.

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