Original Article - Prospective Study

Three-dimensional Locking Plate and Conventional Miniplates in the Treatment of Mandibular Anterior Fractures

Nilima J. Budhraja, Ramakrishna S. Shenoi, Samprati J. Badjate, Kshitij O. Bang, Pranav D. Ingole, Vrinda S. Kolte
Department of Oral and Maxillofacial Surgery, VSPM's Dental College and Research Center, Nagpur, Maharashtra, India

Abstract

Context: Three-dimensional (3D) locking plates has been designed with the hypothesis that this will overcome the disadvantages of both the systems and also advantages of both systems will be combined for the management of mandibular fractures. **Aims:** The purpose of this study was to evaluate the efficacy of 2-mm 3D locking miniplate in the management of anterior mandibular fracture and to compare it with Champy's miniplate. **Settings and Design:** A prospective, randomized, clinical trial was carried out in thirty patients who were divided equally in two groups. **Subjects and Methods:** Group I and Group II patients were treated with 2-mm 3D locking plates and 2-mm standard miniplates, respectively. They were evaluated according to the outcomes of the study, that is, working time, wound dehiscence, infection, segmental mobility, postoperative occlusion, need for postoperative intermaxillary fixation (IMF), and radiological evaluation of reduction and fixation. **Statistical Analysis Used:** Student's *t*-test and Mann–Whitney test were used to compare the two systems. The data were analyzed using Statistical Package for the Social Science version 14.0. The *P* value was taken as significant when <0.05 (confidence interval of 95% was taken). **Results:** The mean duration of procedure for Group I was found to be 49.33 min, whereas for Group II was 59.67 min. There was significantly greater pain on day 1 and at 1 week in Group II patients. 6.7% ($n = 1$) of both groups showed incidence of infection. Postoperative stability was adequate in most cases except in one patient ($n = 1$) of 3D locking system, which was revealed as postoperative occlusal disharmony, unsatisfactory radiological reduction of the fracture fragments, and the segmental mobility. There was no incidence of wound dehiscence, tooth damage, and nerve damage in either group. **Conclusions:** The result of the study can conclude that there is no major difference between both systems in terms of treatment outcome.

Keywords: Anterior mandibular fracture, Champy's miniplate, interforaminal mandibular fracture, standard miniplate, three-dimensional locking miniplate

Introduction

Over the years, the methods to treat mandibular fractures have undergone many refinements. Newer methods have been tried and older ones have had improvements. Two approaches to mandibular fracture fixation have evolved; one is rigid stabilization, proposed by Spiessl,[1] and the other semi-rigid fixation, proposed by Champy *et al*.[2,3] Both techniques have disadvantages, as adaptation of the plate to bone is difficult and time-consuming with rigid fixation while fracture stability cannot be guaranteed with semi-rigid stabilization.[4] A three-dimensional (3D) plate may overcome these shortcomings.

Farmand and Dupoirieux[5] developed the concept of 3D miniplates whose shape is based on the principle of the quadrangle as a geometrically stable configuration for support. The basic form is quadrangular with 2 × 2 hole square plate and 3 × 2 or 4 × 2 hole rectangular plate. The plates are adapted to the bone according to Champy's principles.

To overcome the disadvantages of loosening of hardware and need of perfect adaptation of traditional miniplate system an internal Mini-Locking-System was developed in collaboration with the AO/ASIF-Institute.[6]

During insertion, the locking screw engages and locks into the threaded plate holes. According to Ellis and Graham,[7]

Access this article online

Quick Response Code:

Website: www.amsjournal.com

DOI: 10.4103/ams.ams_175_17

Address for correspondence: Dr. Nilima J. Budhraja, 403, Vighnaharta Apartment, Chitale Marg, Dhantoli, Nagpur, Maharashtra, India.
E-mail: nilimabudhraja@gmail.com

How to cite this article: Budhraja NJ, Shenoi RS, Badjate SJ, Bang KO, Ingole PD, Kolte VS. Three-dimensional locking plate and conventional miniplates in the treatment of mandibular anterior fractures. Ann Maxillofac Surg 2018;8:73-7.

Locking plate systems offer certain advantages over other plate systems. The theoretical advantages of locking system are: (1) increases construct stability; (2) minimizes the risk of stripped screw holes; (3) decreases risk of screw back-out and subsequent loss of reduction; (4) provides a positive stop for locking screws when inserted by power; (5) reduces the need for precise anatomic plate contouring with the underlying bone, making plate adaptation easier; and (6) preserves reduction intraoperatively by maintaining plate-to-bone position.

Three-dimensional miniplate gives 3D stability to the fractured segments during healing. Locking system does not allow screw loosening and alteration in bone alignment or occlusal discrepancies on screw tightening. Three-dimensional locking plates have been designed with the hypothesis that this will overcome the disadvantages of the both the systems and also advantages of both systems will be combined for the management of mandibular fractures.

Considering the above background, a study was conducted to compare and evaluate 2-mm Champy's miniplates and 2-mm 3D locking plates in terms of treatment outcome in the management of anterior mandibular anterior fractures.

Upon scouring the literature, there have been limited studies to compare the 3D locking plate with standard miniplates.[8,9]

Subjects and Methods

A prospective, randomized, clinical trial was carried out in department of oral and maxillofacial surgery over 2 years after obtaining ethical and research committee approval. Informed consent was obtained and patients of both genders within the age group 18–50 years with isolated displaced noncomminuted anterior mandibular fractures were included.

Patients with preoperative infection at the site of fracture, medically compromised, mixed dentition, or with less mandibular vertical height between root apex of teeth and lower border of mandible presuming that 3D plate would not fit a vertically short mandible were excluded from the study.

After assessing for eligibility, thirty patients (n = 30) were divided randomly by lottery method into 2 groups. Group I (n = 15) was treated open reduction and internal fixation using 2-mm 3D locking stainless steel plates (S. K. Surgicals, Pune, India) and Group II (n = 15) with 2-mm stainless steel standard miniplate (S. K. Surgicals, Pune, India) using Champy's principles of osteosynthesis.

Patients were posted for surgery under all aseptic precautions, under general anesthesia and were administered injection cefotaxime 2 g intravenous (i.v.) 1-h before the surgery as prophylactic antibiotic and same was continued (injection cefotaxime 1 g i.v.) twice a day for 5 days postoperatively.

Intraoral translabial incision was placed, fracture site was identified, reduced, and temporary IMF was placed, and satisfactory occlusion was achieved. Fixation was done either using a 3D locking 2-mm stainless steel plate [Figures 1-3] or two standard miniplates and 2 mm × 8 mm screws using Champy's principles of osteosynthesis [Figure 4].

Three-dimensional locking plates were placed in the way as described by Farmand and Dupoirieux,[5] in which the horizontal bars were perpendicular to fracture line and vertical ones were parallel to it.

After plate fixation, the occlusion was verified again, and surgical site was copiously irrigated with 5% povidone-iodine and followed by normal saline. IMF was removed. Hemostasis was achieved and closure was done. Operating time from incision to wound closure was noted. Postoperative IMF was avoided and preferred only when occlusion was deranged postoperatively.

Soft diet was recommended for six weeks postoperatively. Follow-up of patient was done for 3 months at the interval of 1 week, 4 weeks, and 3 months. They were reviewed by senior oral and maxillofacial surgeon who was blinded to the parameters of the study, that is, wound dehiscence, infection, segmental mobility, postoperative occlusion, need for postoperative IMF, need for plate removal, and radiological evaluation of reduction and fixation.

Visual analog scale was used for recording preoperative and postoperative pain. Infection was assessed using criteria for surgical site infection[10] as well as radiolucency surrounding the screws in the radiographs. Statistical analysis was carried out employing Student's t-test and Mann–Whitney test to compare the two systems. The data were analyzed using Statistical Package for Social Science version 14.0. The P value was taken as significant when <0.05 (confidence interval of 95% was taken).

Results

Among the study population, all patients were dentate, males of third decade (66.7%) were commonly involved and the most common etiology was road traffic accidents (70%). Symphysis and parasymphysis fracture was found in 31.7% and 68.3% cases, respectively.

The average period between time of trauma and hospital consultation was 2 days, and the average period between first consultation and surgery was 4 days involving both the groups.

The mean duration of procedure for Group I was 49.33 min, whereas for Group II was 59.67 min. There was significantly greater pain on day 1 and at 1 week in Group II patients (P = 0.004), but there was no significant difference between the two groups at 1 month.

Incidence of infection was shown at 6.7% (n = 1) in both groups. Postoperative stability was adequate in most cases except that of oblique fracture, which was reflected in 6.7% (n = 1) of Group I patients as postoperative occlusal disharmony, unsatisfactory radiological reduction of the fracture fragments, and segmental mobility, thus treated with postoperative IMF for 3 weeks. There

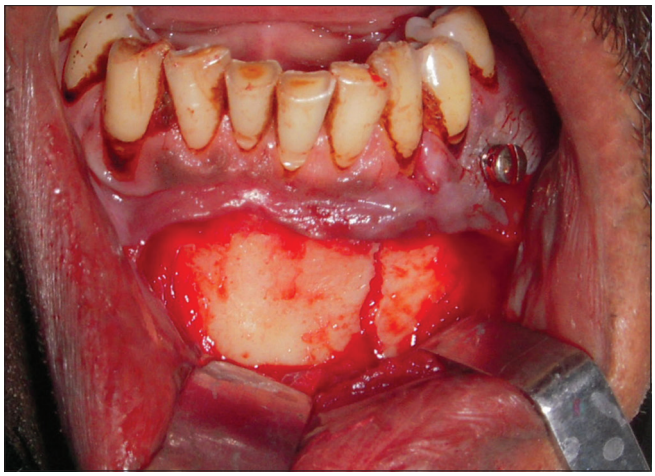

Figure 1: Fracture in left parasymphysis region

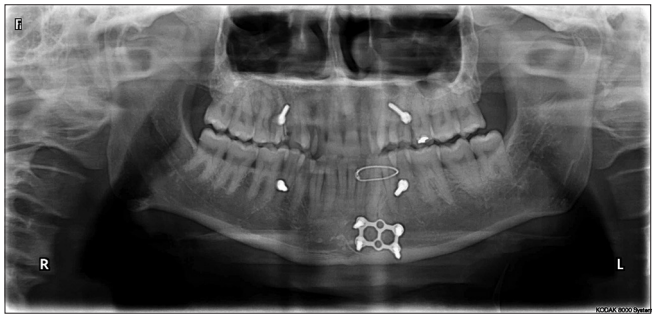

Figure 3: Orthopantomogram showing fixation with three-dimensional locking plate

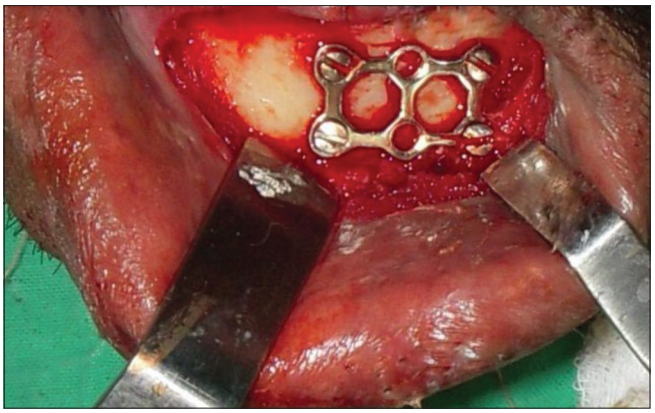

Figure 2: Fixation three-dimensional locking plate

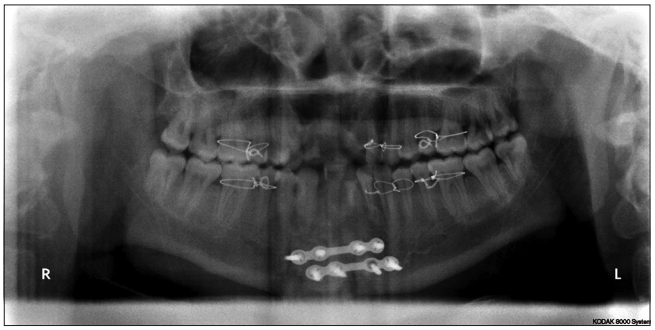

Figure 4: Orthopantomogram showing fixation with Champy's miniplates

was no incidence of tooth damage and nerve damage in either group. Clinical and radiological parameters are compared and summarized in Table 1.

Discussion

Principles of 3D locking design rely on principles of 3D Miniplates system and locking system. First, when the mandible is in function, primary forces of concern are bending, vertical displacement and shearing. In 3D plate, the vertical bars connecting the two horizontal bars resist bending forces. The box configuration of the plate distributes the forces over a surface area and not along a single line; this provides more stability in three dimensions; against torsion forces, vertical displacement, bending and shearing forces. Thus, the stability is gained in three dimensions, hence the name 3D plate.

In the locking system, the screw and plate becomes a single rigid functional unit that no longer relies on the bone to plate interface for stabilization.[11] The locking system combines two principles[6]: First, the locking system prevents stripping of screws and prevents movement and loosening of screws; and second, fixator principle simplifies bending of plates and decreases torsion or opening at the fracture site. The absence of pressure underneath the plate prevents interference with the vascular supply of the bone and allows periosteum growing under the plates promote fracture healing.

Table 1: Comparison of various clinical and radiological parameters between Group I and Group II

Clinical and radiological parameters	Group I (n=15)	Group II (n=15)
Duration of surgery (min)	49.33	59.67
Postoperative occlusal disturbance on day 1	1	0
Postoperative segmental mobility on day 1	1	0
Radiological reduction (not satisfactory)	1	0
Infection at 3rd month	0	1
Screw loosening	0	1
Need for intermaxillary fixation	1	0

According to Goyal *et al*.,[9] it is not clear if the increased biomechanical stability in the 3D locking plate is due to design of plate or due to the locking system.

The average operating time required for the placement of 3D locking plate was approximately 10.34 min less than placement of Champy's miniplate. These findings were similar to the results of a study by Zix *et al*.,[12] Jain *et al*.,[8] and Barde *et al*.[13] on 3D plate who reported reduced average operating time. Collins *et al*.[14] found that the average operating time with locking system was 6.65 min shorter than the standard plate/screw system. Simplified adaptation to bone as well as simultaneous stabilization at both the superior and inferior borders makes the 3D locking plate a time-saving alternative to conventional miniplates.

In our study, postoperative stability was adequate in most cases except in the oblique fractures (n = 1) of Group I. This might be due to difficulty in achieving principles of 3D plate fixation, that is, horizontal bar is perpendicular and vertical bar is parallel to the fracture line.[15] Postoperative occlusal discrepancy was treated successfully by placing IMF for 3 weeks. Two cases (10%) of mild segmental mobility were noted by Jain *et al*.[15] In both the cases 3D plate fixation was used for the treatment of oblique fractures.

According to Andrew *et al*.[16] the symphyseal fractures are under greater degree of torsional strain, hence 3D plates provide higher stability in this region. Alkan *et al*.[17] carried out an *in vitro* study to evaluate the biomechanical behavior of four different types of rigid fixation systems with semi-rigid fixation system that are being currently used. This study demonstrated that 3D strut plates have greater resistance to compression loads than the Champy's technique.

Infection in one case of Group I, during the 1st week of follow-up was found to be superficial incisional SSI which was treated by drainage of pus, wound debridement under antibiotic coverage for 5 days (tablet cefixime 200 mg bid and tablet metronidazole 400 mg tid). One patient of Group II during 3rd month of follow-up had a draining sinus tract. On radiographic examination, radiolucency surrounding the screws was found. Hardware removal under antibiotic coverage (tablet cefixime 200 mg b.i.d and tablet Metronidazole 400 mg tid) and sinus tract excision was done. While on removal of plate, it was observed that the screws were loose and deformation of the plate was noted. Guimond *et al*.[18] reported an infection rate of 5.4% (n = 2), whereas Feledy *et al*.[19] reported 9% infection rate (n = 2) with the use of 3D plate. As it has been claimed that mobility of fractured segments is a causative factor in postoperative infections, the improvement of plate stability might be a way to minimize this problem.

In the present study, none of the cases showed injury to the tooth. Jain *et al*.[15] reported 2 cases of injury to the roots while treating the fractures near mental foramen using 3D miniplate fixation.

In our study, no cases in either group showed plate fracture in follow-up. In analyzing the cause of plate fracture, several factors have to be considered, besides the technical aspects, such as the material and the form of the plate, there are some surgical factors which contribute to weakening of the plate. Since locking system is incorporated in 3D locking plate, it is unnecessary for the plate to have intimate contact with the underlying bone in all areas, so multiple bending of the plate for the adaptation was not required and this reducing the chances of plate fracture.

The results suggest that fixation of mandibular anterior fracture with 3D locking plates provides 3D stability, carries low infection rates and shorter operative time because of simplified adaptation to the bone and simultaneous stabilization at both superior and inferior borders. As far as cost-benefit ratio is considered the single 3D locking plate cost less than Champy's plate as there reduction in number of screws by 50%. The 3D locking miniplate system may be considered inconvenient to use in cases of oblique fractures and in fractures involving the mental nerve area. The other probable limitations of these plates could be the excessive implant material due to extra vertical bars incorporated for countering the torque forces which is in agreement with Parmar *et al*.[20]

Although experimental studies on biomechanics have confirmed sufficient stability of the 3D plating system,[21,22] only a few clinical studies are reported in literature.[18,20,23,24] The use of 3D miniplates in mandibular fracture fixation has not yet become established. In published survey by Gear *et al*.,[25] among 104 AO/ASIF surgeons, only 6% use this type of plate. But with the incorporation of locking system in 3D plate obviate the need for precise adaption and it is unnecessary for the plate to have intimate contact with bone thus now 3D locking plate could be a considered as the better option for management mandibular anterior fractures.[9] If we avoid placing 3D plate in oblique fracture then it can be assumed that combined properties of 3D plate and locking plate will provide better treatment outcome as compared to Champy's miniplates. Jain *et al*.[8] suggested the use of 3D holed 2-mm miniplate for the management of isolated mandibular anterior fracture.

Conclusion

On the basis of this study, we can conclude that 3D locking plate is an alternative approach with a similar outcome profile to miniplates. A similar study with large sample size would give definitive results.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Spiessl B. Rigid internal fixation of fractures of the lower jaw. Reconstr Surg Traumatol 1972;13:124-40.
2. Champy M, Loddé JP, Schmitt R, Jaeger JH, Muster D. Mandibular osteosynthesis by miniature screwed plates via a buccal approach. J Oral Maxillofac Surg 1978;6:14-21.
3. Michelet FX, Deymes J, Dessus B. Osteosynthesis with miniaturized screwed plates in maxillofacial surgery. J Oral Maxillofac Surg 1973;1:79-84.
4. Kroon FH, Mathisson M, Cordey JR, Rahn BA. The use of miniplates in mandibular fractures. An *in vitro* study. J Craniomaxillofac Surg 1991;19:199-204.

5. Farmand M, Dupoirieux L. The value of 3-dimensional plates in maxillofacial surgery. Rev Stomatol Chir Maxillofac 1992;93:353-7.
6. Gutwald R, Alpert B, Schmelzeisen R. Principle and stability of locking plates. Keio J Med 2003;52:21-4.
7. Ellis E 3rd, Graham J. Use of a 2.0-mm locking plate/screw system for mandibular fracture surgery. J Oral Maxillofac Surg 2002;60:642-5.
8. Jain MK, Sankar K, Ramesh C, Bhatta R. Management of mandibular interforaminal fractures using 3 dimensional locking and standard titanium miniplates – A comparative preliminary report of 10 cases. J Craniomaxillofac Surg 2012;40:e475-8.
9. Goyal M, Marya K, Chawla S, Pandey R. Mandibular osteosynthesis: A Comparative evaluation of two different fixation systems using 2.0 mm titanium miniplates and 3-D locking plates. J Maxillofac Oral Surg 2011;10:32-7.
10. Mangram AJ, Horan TC, Pearson ML, Silver LC, Jarvis WR. Guideline for prevention of surgical site infection, 1999. Hospital infection control practices advisory committee. Infect Control Hosp Epidemiol 1999;20:250-78.
11. Haug RH, Street CC, Goltz M. Does plate adaptation affect stability? A biomechanical comparison of locking and nonlocking plates. J Oral Maxillofac Surg 2002;60:1319-26.
12. Zix J, Lieger O, Iizuka T. Use of straight and curved 3-dimensional titanium miniplates for fracture fixation at the mandibular angle. J Oral Maxillofac Surg 2007;65:1758-63.
13. Barde DH, Mudhol A, Ali FM, Madan RS, Kar S, Ustaad F, *et al.* Efficacy of 3-dimensional plates over champys miniplates in mandibular anterior fractures. J Int Oral Health 2014;6:20-6.
14. Collins CP, Pirinjian-Leonard G, Tolas A, Alcalde R. A prospective randomized clinical trial comparing 2.0-mm locking plates to 2.0-mm Standard Plates in Treatment of Mandible Fractures. J Oral Maxillofac Surg 2004;62:1392-5.
15. Jain MK, Manjunath KS, Bhagwan BK, Shah DK. Comparison of 3-dimensional and standard miniplate fixation in the management of mandibular fractures. J Oral Maxillofac Surg 2010;68:1568-72.
16. Gear AJ, Apasova E, SchmitzJP.Treatment modalities for mandibular fractures. J Oral Maxillofac Surg 2005;63:655-63.
17. Alkan A, Celebi N, Ozden B, Baş B, Inal S. Biomechanical comparison of different plating techniques in repair of mandibular angle fractures. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2007;104:752-6.
18. Guimond C, Johnson JV, Marchena JM. Fixation of mandibular angle fractures with a 2.0-mm 3-dimensional curved angle strut plate. J Oral Maxillofac Surg 2005;63:209-14.
19. Feledy J, Caterson EJ, Steger S, Stal S, Hollier L. Treatment of mandibular angle fractures with a matrix miniplate: A preliminary report. Plast Reconstr Surg 2004;114:1711-6.
20. Parmar BS, Menat S, Raghani M, Kapadia T. Three dimensional miniplate rigid fixation in fracture mandible. J Maxillofac Oral Surg 2007;6:14-6.
21. Wittenberg JM, Mukherjee DP, Smith BR, Kruse RN. Biomechanical evaluation of new fixation devices for mandibular angle fractures. Int J Oral Maxillofac Surg 1997;26:68-73.
22. Piffkò J, Homann Ch, Schuon R, Joos U, Meyer U. Experimental study on the biomechanical stability of different internal fixators for use in the mandible. Mund Kiefer Gesichtschir 2003;7:1-6.
23. Wittenberg JM, Smith BR, Trigg DD. Treatment of mandibular fractures with 3D titanium miniplates. J Oral Maxillofac Surg 1994;52:106.
24. Anand SS, Thangavelu A. Role of indigenous 3Dimensional titanium plating system in oral and maxillofacial surgery. J Maxillofac Oral Surg 2004;3:24-7.
25. Gear AJ, Apasova E, Schmitz JP, Schubert W. Treatment modalities for mandibular angle fractures. J Oral Maxillofac Surg 2005;63:655-63.