A Comparative Evaluation of Fixation Techniques in Anterior Mandibular Fractures Using 2.0 mm Monocortical Titanium Miniplates Versus 2.4 mm Cortical Titanium Lag Screws

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Abstract

Objective To compare the efficacy and surgical outcome of treatment of anterior mandibular fracture using either 2.0 mm titanium miniplate or 2.4 mm titanium lag screw technique.

Materials and Methods A total of 30 patients were managed by open reduction and internal fixation utilizing the miniplate and lag screw technique for fractures of anterior mandible. The patients were randomly divided into two groups. Group I: (15 patients) were treated with Leibinger, 2.0 mm titanium mini plates system with self-tapping screws and Group II: (15 patients) were treated with 2.4 mm cortical lag screw (Synthes). Intraoperatively duration of surgery was measured from the time incision was placed till the closure of wound. Subsequent follow up was done at 3, 6, 12, 24 weeks, postoperatively. During every follow up, patients were assessed clinically for malocclusion, neurosensory deficit, biting efficiency, implant failure, mal-union/non-union. Pre and postoperative radiographs were taken to assess the gap between fracture segments. Results were evaluated using Chi square and the unpaired *t* test.

Results In our study, the mean duration of surgery (hours) was 1.97 ± 0.52 for group I and 1.26 ± 0.55 for group II. The difference was found to be statistically significant (*p* value 0.001). i.e. more time was taken in case of surgery with mini-plates when compared to the lag screw. Short surgical procedure reduces the incidence of infectious complications, which significantly lowers the financial

burden. The mean post-operative radiographic distance between all measuring points were considerably more in case of mini-plate group as compared to lag screw group. Lag screw group showed faster improvement in terms of biting efficiency as compared to mini-plate group which showed a tendency to masticate only medium hard food items by 24 weeks. In both groups, no postoperative malocclusion was noted. In initial weeks, neurosensory deficit was seen more in mini-plate group as compared to lag screw group but after six weeks all patients showed improvement in neurosensory function without any permanent nerve damage.

Conclusion According to this prospective study, rigid internal fixation provided by lag screw technique for anterior mandibular fracture offers several advantages over conventional bone plating. It is an excellent means of achieving rapid and safe fixation which is followed by primary bone healing in anterior mandibular fractures, without any major complications.

Keywords Mandibular fractures · Miniplates · Compression osteosynthesis · Lag screw technique

Introduction

Fracture of mandible occurs more frequently than any other fracture of facial skeleton and they outnumber zygomatic and maxillary fractures by a ratio of 6:2:1 respectively. The etiology of mandibular fractures mainly includes assaults, road traffic accidents (RTA), falls and sports injuries [1]. Although there is a wide variance in the reported percentage of fractures of the anterior mandible, aggregate analysis places this at approximately 17% of all mandibular fractures [2].

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By and large, the therapeutic goal of any fracture management is to restore original anatomic form and function at the earliest without least morbidity. Ideally, this should be accomplished expeditiously and with least patient discomfort. The management of mandibular fractures has evolved significantly in the past half century. Historically these fractures were managed through closed techniques, such as maxillomandibular fixation (MMF), splints, and external fixation. The modern era of fracture treatment has given the way to the use of rigid internal fixation to allow rapid return of function and significantly shorter convalescence [3].

Spissel and Schroll [4] in 1972 presented a plate fixation system which was applied to the lower border of mandible; ‘biomechanically—the most unfavorable site’. In spite of this, it provides a dynamic compression system of plates and bicortical screws, which gives perfect stability to the fractured segment. However, Cawood [5] in 1993 highlighted the drawbacks of this plating system. When this compression plate is applied to the lower border (site of compression) of mandible, it becomes biomechanically unfavorable. This results in distraction at the upper border of the mandible along the alveolar ridge. Moreover, the application of compression plate to the convex (buccal) surface of the mandible results in a distraction of the fracture along the lingual cortical plate which is difficult to overcome. Apart from this it is bulky, difficult to adapt and usually requires an extraoral incision. To prevail over these limitations, Champy et al. [6] in 1976 devised another plating system developed by Michelet to treat mandibular fractures.

Open reduction and, internal fixation of mandibular fractures, using plates has become a widely accepted method during the past three decades. In contrast to orthopedic surgery, lag screws play a vital role in maxillofacial osteosynthesis.

Lag Screw technique was first described by Brons and Boering [7] who postulated that lag screw not only immobilize the fracture fragments but also produce a constant compression of the fracture area. Others have similarly illustrated the versatility of lag screws for mandibular fractures [8].

The anterior mandible, between the two mental foramina, is uniquely suited to the application of lag screw fixation for three reasons. The most important is the curvature of the anterior mandible. This allows placements of lag screws across the symphysis, from one side to other, for sagittal fractures, and from anterior to posterior for oblique fractures and those of the anterior body region. The second reason the anterior mandible is well suited to lag screw fixation is the thickness of the bony cortices, which provide extremely secure fixation when the screws are properly inserted. Finally there are no anatomic

hazards below the apices of the teeth until the mental foramina are encountered. This makes lag screw placement extremely simple, safe and reliable in anterior mandibular fractures [9].

Considering this, the purpose of the present study is to compare fixation techniques in anterior mandibular fractures using 2.0 mm monocortical titanium miniplates versus 2.4 mm cortical titanium lag screws.

Materials and Methods

Thirty patients of mandibular fracture within the age group of 16–60 years were selected irrespective of their caste, creed & sex from the Department of Oral & Maxillofacial Surgery, Santosh Medical & Dental College & Hospital, Ghaziabad.

They were divided randomly into two groups. Group I: (15 patients) were treated with Leibinger standard Wurzburg 2.0 mm titanium mini plates system with self-tapping screws (Fig. 1). Group II: (15 patients) were treated with 2.4 mm cortical lag screw (Synthes) (Fig. 2).

Lag screws are primarily used for the stabilization of oblique fracture. It can also be used after sagittal split osteotomy and for fracture of body and angle of mandible, but they have limited use in midface region except in oblique fractures of periorbital or nasal regions, owing to the insufficient thickness of the midfacial bones which are too thin to permit the placement of screws.

The inclusion criteria was patients with fracture of symphysis and parasymphysis region of mandible, Patients medically fit for surgery under general anesthesia or local anesthesia, patients within the age group of 16–60 years, Patients were informed about closed or open reduction procedures. The individuals who were willing for surgery were included in the study.

Patient with Comminuted mandibular fractures, Pathologic fractures, Hematological disorders and any other associated midface fracture were excluded from this study.

All clinical and radiographic parameters were evaluated. Malocclusion, Sensory Deficit, Infection, Wound Dehiscence, Biting efficiency were evaluated at regular interval of 3, 6, 12, 24 weeks postoperatively.

Radiographic Evaluation was evaluated by measuring the gap between the fractured fragments of the mandible in the pre- and postoperative radiographs. Panoramic view was the main parameter for this evaluation. These X-rays were performed within 1 day after surgery. On the radiographs, a line was drawn along the fracture and it was divided into 3 equal parts. Perpendicular lines were projected onto the fracture line for reproducible measure points. Measurements of the fracture gap were conducted

Fig. 1 **a** 16 year old male patient with right parasymphysis fracture and left angle fracture. **b** Pre op OPG. **c** Two miniplates secured at the fracture site. **d** Post-operative view of corrected occlusion. **e** Fracture mandible treated with Miniplate (Group I)

on these 4 defined points by using a precision digital caliper, as described by Schaaf et al. [10] (Fig. 3). Radiological data of these patients was evaluated. The distance between the fractured fragments of the mandible in the pre and postoperative radiographic panoramic view was recorded using the four defined measuring points. On the radiographs, a line was drawn along the fracture line and it was divided into three equal parts. Perpendicular lines were projected onto the fracture line for reproducible measure points. Results were evaluated using Chi square and the unpaired *t* test.

Results

Thirty patients of mandibular fracture were included in this randomized control in vivo study. These patients were randomly allocated to either of two groups. Group I (control group) patients were treated with 2.0 mm conventional monocortical titanium miniplates and group II (test group) were treated with 2.4 mm cortical titanium lag screw. In our study, male predominance (90%) with male: female ratio 9:1 was observed. Maximum number of patients encountered in this study fall in age group of 15–25 years.

Fig. 2 **a** 26 year old male patient with right parasymphysis fracture of mandible. **b** Pre-operative OPG showing right parasymphysis fracture. **c** Two lag screws of 26 mm being placed on prepared site, to achieve axial compression across fracture line. **d** Post-operative view

of corrected occlusion (lag screw). **e** Immediate post-operative OPG showing two lag screws of 26 mm length placed achieving good axial compression

The etiological factors of mandibular fractures were noted. RTA was leading cause (53.3%) of mandibular fractures, followed by assaults (23%). The relative difference seems

to be related to the social make up of the locality studied. The incidence of various fracture sites among the total patient was noted. The most common site was

Fig. 3 **a** On the OPG, the fracture lines (both borders) were traced onto a acetate sheet and it was divided into three similar parts. Thus, 4 measuring points were generated by perpendicular projection onto the fracture line. **b** Fracture mandible treated with Miniplate (Group I). **c** Fracture mandible treated with Lag Screw (Group II)

parasymphysis (65%) followed by angle (25.6%), symphysis (4.7%) and body (4.7%).

The mean duration of surgery (hours) was 1.97 ± 0.52 for (Miniplates) group I and 1.26 ± 0.55 for group II (lag screw). The mean duration of surgery (hours) was compared using the unpaired *t* test. The difference was found to be statistically significant (*p* value < 0.05) (Table 1). i.e. more time was taken in case of surgery with mini-plates when compared to the lag screw (Graph 1).

The mean Pre-operative radiographic evaluation of distances in (mm) at point 1— 3.05 ± 2.11 , point 2— 2.36 ± 0.86 , point 3— 2.14 ± 1.21 and point 4— 2.21 ± 0.84 were measured in mini-plate group. Amid the lag screws all measuring distances at point 1—

Table 1 Mean duration of surgery

	Implant used	Mean	Std. deviation	Sig. (<i>p</i> value)
Duration of surgery (hours)	Miniplates	1.97	0.52	0.001*
	Lag screws	1.26	0.55

Graph 1 **a** Mean Duration of surgery. **b** Mean Duration of surgery (SEM Bars)

2.27 ± 1.36 , Point 2— 2.31 ± 1.34 , Point 3— 2.33 ± 1.87 and Point 4— 2.24 ± 2.07 were recorded. The mean pre-operative radiographic evaluation (distance between fracture fragments in mm.) Point 1, point 2, point 3, and point 4 the mini-plates and the lag screws was compared using the unpaired *t* test. The difference was found to be statistically insignificant (*p* value < 0.05) as shown in (Table 2).

The mean Post-operative radiographic evaluation (distance between fracture fragments in mm.) of all distances at Point 1— 1.11 ± 0.48 point 2— 1.32 ± 0.68 , point 3— 1.08 ± 0.43 , point 4— 0.89 ± 0.48 were measured in mini-plate group. Among the lag screws the distance at point 1 was 0.9 ± 0.41 , Point 2— 0.21 ± 0.31 , Point 3— 0.17 ± 0.22 . Point 4— 0.10 ± 0.17 were measured as shown in (Table 3).

Table 2 Preoperative radiographic evaluation

Preoperative radiographic evaluation	Implant used	Mean	Std. deviation	Sig. (<i>p</i> value)
Radiographic evaluation (distance between fracture fragments in mm.)—Point 1	Miniplate	3.05	2.11	0.238
	Lag screw	2.27	1.36	
Radiographic evaluation (distance between fracture fragments in mm.)—Point 2	Miniplate	2.36	0.86	0.908
	Lag screw	2.31	1.34	
Radiographic evaluation (distance between fracture fragments in mm.)—Point 3	Miniplate	2.14	1.21	0.746
	Lag screw	2.33	1.87	
Radiographic evaluation (distance between fracture fragments in mm.)—Point 4	Miniplate	2.21	0.84	0.956
	Lag screw	2.24	2.07	

Table 3 Postoperative radiographic evaluation

Post-operative radiographic evaluation	Implant used	Mean	Std. deviation	Sig. (<i>p</i> value)
Radiographic evaluation (distance between fracture fragments in mm.)—Point 1	Miniplate	1.11	0.48	0.000*
	Lag screw	0.29	0.41	
Radiographic evaluation (distance between fracture fragments in mm.)—Point 2	Miniplate	1.32	0.68	0.000*
	Lag screw	0.21	0.31	
Radiographic evaluation (distance between fracture fragments in mm.)—Point 3	Miniplate	1.08	0.43	0.000*
	Lag screw	0.17	0.22	
Radiographic evaluation (distance between fracture fragments in mm.)—Point 4	Miniplate	0.89	0.48	0.000*
	Lag screw	0.10	0.17	

The mean Radiographic evaluation (distance between fracture fragments in mm.)—point 1, point 2, point 3, point 4 among the miniplates and among the lag screws was compared using the unpaired *t* test. The difference was found to be statistically significant (*p* value < 0.05). It is evident that mean post-operative radiographic distance between all measuring points was considerably more in case of mini-plate group as compared to lag screw group.

Post operatively, all parameters Malocclusion, Sensory Deficit, Infection, Wound Dehiscence, Biting efficiency were evaluated at regular interval of 3, 6, 12, 24 weeks. Postoperatively, no malocclusion was noted in any operated patient in both the groups.

The sensory deficit was present in 5 (33.33%) cases of the mini-plates in initial 3 weeks whereas it was present in 2 (13.3%) cases of Lag screw at 3 weeks. The sensory deficit was compared between patients with mini-plate and lag screw at 3 weeks using the Chi square test. The difference was found to be statistically insignificant (*p* value > 0.05). After 6 weeks there was no sensory deficit present in both the groups.

There was no post-operative infection in group II at succeeding 6, 12 and 24 weeks. But it was present in 1 (6.7%) case of miniplates at 24 weeks. The relationship between post-operative infection was compared at 3, 6, 12 and 24 weeks using the Chi square test.

There was wound dehiscence present in 1 (6.7%) case with mini-plate as well as in lag screw group (6.7%) at all intervals. The relationship between Wound dehiscence and type of implant was compared at all weeks using the Chi square test. The difference was found to be statistically insignificant (*p* value > 0.05) (Graph 2).

The biting efficiency was evaluated and general trends towards intake of soft diet were seen in both groups for first 3 weeks. In total healing period of 6–24 weeks, in Group I 73.3% patients were on normal diet, while group II showed 93.3% patients were able to chew normal diet. This shows

Graph 2 Post-operative complications

Graph 3 Post-operative evaluation (Biting Efficiency)

there was improvement in biting efficiency of patients of group II. The difference was found to be statistically significant (p value < 0.05) at all the intervals (Graph 3).

Discussion

In our study, the incidence of mandibular fracture was more in males which is similar to the studies done by various authors [11, 12]. This may be justified by the fact that males are generally more prone to situations like road traffic accidents, sports activity etc. The present study included patients within the age group of 16–60 years; commonly affected age group in our study was 21–30 years. The foremost cause of mandibular fracture was road traffic accident (53.30%) followed by assault (23.3%) fall 20%, sports 3.3%. which is similar to other studies conducted by Madan et al. [13], Ranton and Wiesenfeld [14].

Duration of surgery was measured from the time incision was placed till the closure of wound. The mean duration of surgery (hours) was 1.97 ± 0.52 h in case of mini-plate whereas 1.26 ± 0.55 h in case of lag screw. This difference was found to be statistically significant (p value < 0.05). Lag screw fixation is relatively quicker as the time consuming task of plate bending and adaptation is obviated. Similar results have been described previously by many authors (Peter and Edward [15], Leonard [16], Alan swimmer [17], Heidrun Schaaf [10]. There are many

advantages of a short surgical procedure as elucidated by various authors like brief hospitalization and decreased incidence of infectious complications, which significantly lowers the financial burden.

Radiographic evaluation was done by measuring the mean preoperative and postoperative distance between fracture fragments in (mm) at Point 1, point 2, point 3, point 4 among the mini-plates and the lag screws. In our study, the mean postoperative radiographs demonstrated a significant reduction in fracture gap in group II (lag screw) as compared to the group I (mini-plate), which is in concurrence with the study of Heidrun Schaaf et al. [10]. The lag-screw method resulted in smaller fracture gaps than the mini-plate as it offers internal fixation for the tension zone of the mandible with good compression on the fragments to support bone healing. The compression effect of the lag screw over the entire fracture gap has been examined in biomechanical studies [18, 19]. Urist and Maclean [20] also pointed that bone contact is a prerequisite to the induction process of stimulating osteogenesis. Likewise Charnley [21] stated that osteogenesis is actually stimulated by compression of the fragments. It is generally accepted that reduction and fixation of the fracture to align the fragments in contact, promotes bone healing [22]. A direct correlation between the fracture gap width and the healing process is given in the literature; Large fracture gaps more than 2 mm cause a delay in fracture healing, due to large amount of cartilage and external callus formation between the fracture fragments as demonstrated in

experimental [23], and clinical investigations [24]. As good reduction of a fracture with small inter-fragmentary gaps is important for its revascularization and healing [25].

The inventors of the lag screw system highlighted the possibility for primary bone healing. If the screws are aligned in a position perpendicular to the fracture line, the fracture segments are forced together, resulting in primary bone healing. Here, the main difference between the mini-plate and lag-screw methods is apparent.

Edward Ellis [9] experienced that the displacement of the bony fragments was much more common during placement of bone plate because the adequacy of plate contouring was not known until screws were inserted and the plate was drawn to the mandible whereas displacement of bone never occurs with the lag screw fixation. Peter and Edward [15] also specified the advantages of lag screw over the use of bone plate that when lag screw properly applied it provides rapid method of internal fixation. As there is no plate to be bent, the insertion of lag screw is quicker, easier and the reduction is more accurate than when bone plates are used. Nicholas Zachariades (1996) [26] affirmed that lag screw technique has inherent advantage over compression plate is that it has no stress-shielding effect on the restored mandible as the functional forces instead of being distributed through the centre of the bone pass through and absorbed by the plate and the cortex to which plate has been attached resulting in local unloading of bone.

In our study, no patients were kept on MMF so their nutritional status was maintained. Their masticatory efficiency was evaluated and general trends towards intake of soft diet were seen in both groups for first 3 weeks. In group I, 86% patients were on soft diet whereas in group II 33.3% patients were on soft diet. Postoperatively at 12–24 weeks, 73.3% of patients of group I were on normal diet, while in group II, 93.3% patients were able to chew normal diet. This shows there was improvement in biting efficiency of patients of group II. In the past four decades, there has been an increasing interest in obtaining more immediate return to normal function by using different methods of direct function with an open reduction allowing anatomical reduction of the fragments. Improved masticatory function favors early recovery of jaw function in terms of mouth opening and bite force, decreases weight loss and also provides rapid return of the patient's function at both physiological and psychological levels.

Every surgical technique has its own share of complications and pitfalls and the surgeon must tread the learning curve to master a new technique. Intraoperatively, we encountered breakage of 1.8 mm drill bit incidentally in our first few cases. The drill bits broke while attempting to drill traction hole and was removed without any further damage. This complication has already being reported by

many authors but Paul Tiwana in (2007) [2] suggested that the surgeons must recognize the appropriate angle required to engage the opposing fracture cortex, and while drilling the traction hole the surgeons must attempt to engage the opposing cortex as perpendicular as possible to avoid forcing the drill. If forced, the drill will be deflected by the inner cortex of the mandible in a “U” shape reflective of the anatomy until the shear strength of the metal bit is exceeded resulting in breakage. Also the surgeons must ensure the drill bit is sharp with no structural defects.

There was wound dehiscence present in 1 (6.7%) patient in group I as well as in group II (6.7%). It is highly likely that the persistence of the metallic fixation resulted in intraoral wound dehiscence as observed in both groups. According to Lamphier and Ziccardi [27] the third most frequent complication associated with mandibular fracture treatment was wound dehiscence (21%). They also found that intraoral wound dehiscence was most frequently seen at the mandibular angle and symphysis region when using intraoral incision design. They concluded as these plates are typically placed at the superior border near or under the incision site, which may lead to tension on wound margin with inadequate blood supply to the mucosa causing marginal breakdown of the wound.

Post-operative paresthesia or sensory deficit in form of slight hypoesthesia in lower lip and chin regions occurred in five (33.33%) cases of mini-plates whereas it was present in two (13.3%) cases of Lag screw group which probably was associated with the fracture line passing in the vicinity of mental foramen. All patients regained normal neurosensory function after 6 weeks. Recent onset neurosensory deficit in immediate postoperative period could also occur due to inadvertent damage or traction on nerve during intraoperative manipulation of fracture fragments.

One case of infection (6.7%) was seen in the group I treated by titanium mini-plates at 12 weeks. Plate was removed, fracture site was curettaged, and oral antibiotics were advised. The fracture site healed without any further impediments. The incidence of postoperative infection noted in our study is similar to 6.1% as described by Iizuka et al. [28] and Iizuka Lindqvist [29]. Rosenberg et al. [30] recommended the removal of titanium plates in case of infection at fracture site. Removal of titanium plates has always been a point of controversy. Disadvantages of the use of miniplate system included the necessity for a second procedure of removal of plate routinely at 3–6 months. Indications for routine removal are two folds: the avoidance of stress shielding of healed fracture and theoretical toxicity of the corroded metal. However, none of the patients in group II (lag screw) required lag screw removal for postoperative infection.

Thus, we can safely conclude that the technique of lag screw fixation is easily executable provided the surgeon is

familiar with the basic principles of rigid internal fixation. So, for linear anterior mandibular fracture it offers a faster technique with very few complications and early return of function as compared to miniplates.

Conclusion

According to this prospective study, rigid internal fixation provided by lag screw technique for anterior mandibular fracture offers several advantages over conventional bone plating. It is an excellent means of achieving rapid and safe fixation which is followed by primary bone healing in anterior mandibular fractures, without any major complications. We can conclude from this clinical study that lag screw fixation of anterior mandibular fracture is a simple and successful method of rigid fixation across fracture segments.

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