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Original Article

Comparative Study of the Efficacy of Titanium Lag Screw and Titanium Miniplates for Internal Fixation of Anterior Mandibular Fractures

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Abstract

Introduction: The maxillofacial skeleton injuries occur due to a variety of causes, such as road traffic accidents, and sports injuries. The mandible is the second most commonly fractured bone of the maxillofacial skeleton because of its position and prominence. Although there is wide variance in the reported percentage of fracture of the anterior mandible (symphysis and parasymphysis), aggregate analysis places this at approximately 17% of all mandibular fractures.

Materials and Methods: This study was conducted on 24 patients with clinical and radiological evidence of the anterior mandibular fracture. The patient was treated with two groups; Group A (*n* - 12) treated with titanium lag screw (2.5 mm lag screw); Group B (*n* - 12) treated with titanium miniplates (2 mm miniplates). Clinical and radiological evaluations were made at 6 months postoperatively. Intraoperatively, duration of surgery was measured from the time incision was placed till the closure of wound.

Results: The results of our study suggest that there were no major differences in stability with lag screw and miniplates. Lag screws have the added advantage of achieving interfragmentary compression and stability with a minimum of implant material. The lag screw principle offers the advantages of fixation using minimal hardware, functional stability, is associated with minimal inflammatory complications and functional restriction, and has a lower incidence of infection when considering the treatment of linear, noncomminuted symphyseal region fractures. The procedure, however, requires more skill and expertise.

Conclusion: The choice of suitable osteosynthesis material is an integral part of a treatment plan. Although the sample size is less, the results of our study suggest that there were no major differences in stability with lag screw and miniplates. Lag screws have the added advantage of achieving interfragmentary compression and stability with a minimum of implant material.

Key words: Anterior mandibular fractures, Lag screws, Miniplates

INTRODUCTION

The maxillofacial skeleton injuries occur due to a variety of causes, such as road traffic accidents, and sports injuries. The mandible is the second most commonly fractured bone of the maxillofacial skeleton because of its position and prominence. Although there is wide variance in the reported percentage of fracture of the anterior mandible (symphysis and parasymphysis), aggregate analysis places this at approximately 17% of all mandibular fractures.[1,2]

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This area has been studied extensively and debate continues regarding the ideal treatment method. Although there is a widely accepted consensus about the need for surgical reduction and fixation of a mandibular fracture, a variety of different treatment modalities have been described. Among them are closed or open reduction, extra oral open reduction and internal fixation with a reconstruction plate, intraoral open reduction and internal fixation using different mini-dynamic compression or noncompression plates and an intraoral approach with lag-screw fixation.[3] Miniplate osteosynthesis was introduced to maxillofacial surgery by Michelet *et al.* in 1973. Miniplate osteosynthesis has caused a revolution in mandibular fracture treatment.

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Modern plating systems provide better handling, higher stability, and less pressure on the bone.[4] The application of a static compression system has been transformed into a dynamic plating system.[5] Anatomical and biomechanical considerations for placing these miniplates improved this method. Osteosynthesis can be reduced to a tension band plate on the upper border of the mandible.[6,7]

One of the most practical methods for open reduction internal fixation of mandibular fractures is the use of lag screw fixation for approximation and stabilization of the fracture segments. The lag screw technique in maxillofacial surgery was first advocated by Brons and Boering in 1970 and was later reintroduced by Niederdellmann *et al.*,[8] who stated that at least two screws were necessary to prevent rotational movement of the fragments in oblique fractures of the mandible. In North America, its use for the management of anterior mandible fractures became popular through the work of Ellis and Ghali.[9] Lag screw fixation is based on the concept of oesteosynthesis by bone compression. A special drilling technique and sequence is followed to establish the desired compression during reduction and stabilization. Compression is achieved because the osteotomy hole in the near cortex (gliding hole) is prepared to a width matching the external diameter of the screw. Therefore, the screw does not engage the near cortex until the screw head is flush with the outer aspect of the cortex. The screw threads on the opposite side of the fracture engage the far cortex, which has been prepared to match the internal diameter of the screw (traction hole). Tightening the screw causes the far cortex to be drawn toward the near cortex, thereby creating compression between the fracture segments. While rigid internal fixation with miniplates is currently considered as the most acceptable technique for stabilization of anterior mandibular fracture, recent studies have reported equally good results with lag screw. Hence, there is need for comparative evaluation of efficacy of miniplate and lag screw in anterior mandibular fracture.

The aim of this study is to compare the post-operative results of two different methods for the treatment of mandibular anterior fractures using the miniplate and lag screw for better reproducibility. The objectives included comparative assessments of their ability;

1. To access adequate primary stability, the need for any supplemental maxillomandibular fixation (MMF).
2. To access the time and ease required to complete the procedures.
3. To access the incidence of post-operative complications such as occlusal derangement, wound dehiscence, wound discharge, infection, postsurgical swelling, and any functional limitation in lower lip function as evidenced by speech articulation.

MATERIALS AND METHODS

Patient with traumatic injury to the mandible reporting to the OPD of Department of Oral and Maxillofacial Surgery of Buddha Institute of Dental Sciences and Hospital was selected. This study was conducted on 24 patients with clinical and radiological evidence of the anterior mandibular fracture. The patient was treated with two groups; Group A (*n* - 12) treated with titanium lag screw (2.5 mm lag screw); Group B (*n* - 12) treated with titanium miniplates (2 mm miniplates).

Inclusion Criteria

- Symphysis/parasymphysis fracture of mandible with no evidence of pus discharge and infection.

Exclusion Criteria

- Comminuted fracture
- Uncontrolled systemic disease
- Mal-union/non-union of fracture segment (due to the previous treatment by other techniques/late treatment)
- Anterior fracture with dentoalveolar fracture
- Anterior Fractures with previous associated pathologies (cysts, tumors).

Surgical Procedure

All cases were treated with aseptic condition under general anesthesia. Access to the fracture site was generally sought through an intraoral approach except where a coexisting laceration is present over the chin region. Exposure of the fracture site was obtained by a standard layered dissection through mucosa, mentalis muscle, and the periosteum. After debridement of the fracture line, MMF is applied using arch bars/Ivy eyelet wiring ligated to the dental arches. Fragments were reduced and held in apposition with a reduction forceps (bone clamp) and confirmed visually by verifying the alignment of the buccal cortex and inferior border. For Group A patients, two 2.5 mm diameter cortical screws were placed using the lag screw principle, with care taken to ensure coaxial preparation of the gliding and pilot holes, adequate enlargement of the gliding hole using 3 mm diameter drills to prevent thread engagement proximally, and preparation of the countersink (Figure 1a). For Group B patients, 2.0 mm miniplates were contoured, applied, and fixed using monocortical screws, in accordance with Champy's principles, along the line of osteosynthesis. A minimum of two screws were placed on either side of the fracture line for each of the bone plates applied (Figure 1b). On completion of the procedure, MMF was released and occlusion verified. The incision was then closed in layers and a pressure dressing was applied to the chin.

Follow-up

The patients were followed up clinically after 24 h, on days 3 and on day 7 postoperatively and then at weekly

intervals for 6 weeks and at monthly intervals for 6 months. They were followed up radiographically with mandibular anterior occlusal radiographs and orthopantomographs in the immediate post-operative period and after 1 month, 3 months, and 6 months (Figure 2a and b).

Method of Collection and Analysis of Data

The clinical and radiological findings were recorded in prestructured preformed and was subjected to statistical analysis.

RESULTS

A total of 24 patients with mandibular fracture requiring open reduction and internal fixation were included in this study. Patients were randomly divided into two equal groups of 12 patients in each group. Group A patients underwent osteosynthesis using Titanium lag screw while Group B patients underwent osteosynthesis using titanium 2 mm miniplates.

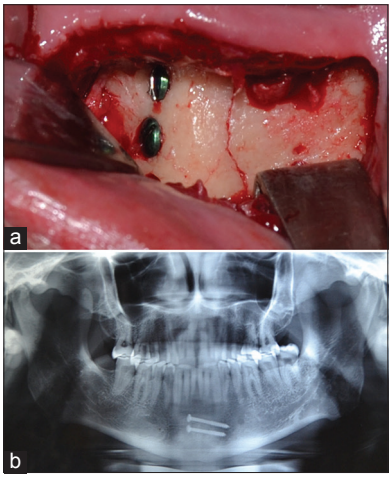

Figure 1: (a) Intraoperative; lag screws fixation. (b) Post-operative; after 6 months radiograph (orthopantomogram)

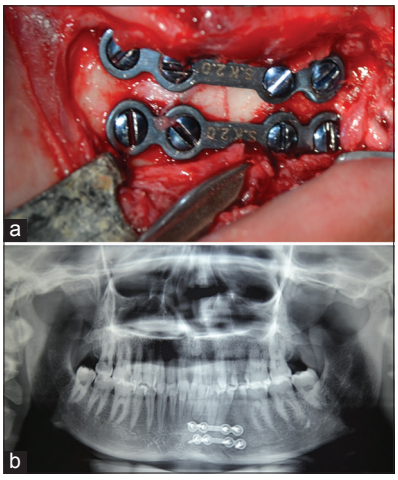

Figure 2: (a) Intraoperative; monocotical plate fixation. (b) After 6 month post-operative radiograph (orthopantomogram)

In our study, male patient was predominance. Out of 24 patients 75% were male and 25% female. The mean value of age in Group A (31.33 ± 12.449) and Group B (22.33 ± 6.800). The etiological factors of mandibular fractures were noted. Road traffic accident, 66.7% was the leading cause of fracture followed by fall 29.2% and assault 4.2%. The operative delay, i.e., the time interval between trauma and surgery ranged from in Group A (10.08 ± 9.793) and in Group B (6.00 ± 3.790).

The majority of patients in Group A, the time needed to complete the procedure ranged from 60 to 90 min (75%), while for the time ranged from 60 to 90 (58.3%) and 90 to 120 min (41.7%). The difference in time required for completion of the procedures between the two groups was found to be statistically significant (Table 1). In Group A, the duration of post-operative swelling varied from a minimum of 5 days in 7 patients (58.3%) and maximum 10 days in 2 patients (16.67%). In Group B, swelling was present for minimum 5 days in 9 patients (75%) and maximum 15 days (16.67%) (Table 2). The mean value pre-operative vertical swelling in Group A (12.583 ± 0.7309) and Group B (12.375 ± 0.8313) and horizontal swelling in Group A (23.600 ± 1.8805) and Group B (23.642 ± 0.7597) and post-operative vertical swelling in Group A (13.725 ± 0.7497) and Group B (13.642 ± 0.8017) and

Table 1: Comparison of time required for procedures

Time required for completion of procedure (min)	Group A *n*=12 (%)	Group B *n*=12 (%)	χ^2 value	*P* value
<30 and<60	2 (16.67)	0 (0)	8.250	0.041*
>60 and<90	9 (75)	7 (58.3)		
>90 and<120	0 (0)	5 (41.7)		
>120 and<150	1 (8.3)	0 (0)		

*Statistically significant differences seen

Table 2: Comparison of the duration of post-operative swelling

Presence of post-operative swelling	Group A (*n*=12)	Group B (*n*=12)	χ^2 value	*P* value
Till 24 h	12 (100)	12 (100)	9.583	0.456#
Till 3 days	12 (100)	10 (83.33)		
Till 5 days	5 (41.67)	9 (75)		
Till 7 days	3 (25)	6 (50)		
Till 10 days	2 (16.67)	7 (58.33)		
Till 15 days	2 (16.67)	2 (16.67)		
Till 1 month	0 (0)	0 (0)		
Till 3 months	1 (8.33)	1 (8.33)		
Till 6 months	0 (0)	0 (0)		

#Nonsignificant differences

horizontal swelling in Group A (25.167 ± 1.2536) and Group B (25.350 ± 0.6816). The difference in magnitude of swelling as assessed by Student's paired *t*-test was not statistically significant (Table 3).

All patient (n = 24) showed restricted lip mobility that affected articulation of speech. In Group A, restricted lip mobility was present for a minimum of 3 days in 6 patients (50%) and to a maximum of 10 days in 2 patients (16.7%). In Group B, restricted lip mobility was presents for a minimum of 3 days in 3 patients (25%), 5 days in 5 patients (41.7%), and maximum 10 days in 2 patients (16.7%). The χ^2 value was 1.833 and p value was 0.608. The difference between the two groups with regard to restriction of lip mobility was statistically significant (Table 4).

Wound dehiscence was not seen both groups. Wound discharge and infection was present, 1 patient in Group A and 1 patient in Group B. Only soft tissue swelling was observed in Group A, occurring in one patient (8.3%). The swelling and discharge was resolved after use of antibiotic therapy. One patient was major complication, which initially responded to antibiotics, but recurrent sinus formation and discharge prompted removal of plates and screws after 3 months. As there was clinically bony union, no further fixation was required. Stability which was obtained in all patient (100%) (Table 5). Postoperatively, a blinded observer evaluated the patients for stability of fixation by manually manipulating the mandible and checking for interfragment mobility at the fracture site. There was no mobility seen in both groups (Table 6).

Table 3: Swelling in Groups A and B: Descriptive statistics

Parameter	N	Mean	SD	SEM
Group A				
Pre vertical	12	12.583	0.7309	0.2110
Post vertical	12	13.725	0.7497	0.2164
Pre horizontal	12	23.600000	1.8805222	0.5428600
Post horizontal	12	25.167	1.2536	0.3619
Group B				
Pre vertical	12	12.375	0.8313	0.2400
Post vertical	12	13.642	0.8017	0.2314
Pre horizontal	12	23.642	0.7597	0.2193
Post horizontal	12	25.350	0.6816	0.1968

SD: Standard deviation, SEM: Standard error of mean

DISCUSSION

This study evaluated the efficacy of miniplates and cortical screws (using the lag screw principle) in open reduction and internal fixation of mandibular symphysis/parasymphysis region fractures.

In our study, the incidence of mandibular fracture was more in males (75%) which is similar to the studies done by various authors.[10,11] This may be justified by the fact that males are generally more prone to situations such as road traffic accidents and sports activity. This study included patients within the age group of 11-60 years; commonly affected mean age in our study was 26.83 years. The foremost cause of mandibular fracture was road traffic accident (66.7%) followed by fall (29.2%), assault (4.2%), which is similar to other studies conducted by Goyal *et al.*[12]

Duration of surgery was measured from the time incision was placed till the closure of wound. The majority of patient in Group A, the time needed to complete the procedure ranged between 60 and 90 min (75%) while for the most Group B time required was 90-120 min. This difference was found to be statistically significant (P = 0.04). Lag screw fixation is relatively quicker as the time consuming task of plate bending and adaptation is obviated. According to Ellis and Ghali, who reported that

Table 4: Comparison of swelling in Group A and Group B by student's paired *t*-test

	Paired samples test							
	Paired differences					*t*	df	Sig. (2-tailed)
	Mean	SD	SEM	95% confidence interval of the difference				
				Lower	Upper			
Group A								
Vertical pre-operative	−1.1417	0.3848	0.1111	−1.3862	−0.8971	−10.276	11	0.000*
Vertical post- operative								
Horizontal pre-operative	−1.5666667	1.6405838	0.4735957	−2.6090439	−0.5242895	−3.308	11	0.007*
Horizontal post-operative								
Group B								
Vertical pre- operative	−1.2667	0.2535	0.0732	−1.4277	−1.1056	−17.312	11	0.000*
Vertical post- operative								
Horizontal pre- operative	−1.7083	0.3450	0.0996	−1.9275	−1.4891	−17.154	11	0.000*
Horizontal post-operative								

*Statistically significant differences. SD: Standard deviation, SEM: Standard error of mean

lag screws could be applied more rapidly as compared to miniplates as the latter require contouring and adaptation, which may be time consuming considering the complexities of the anterior mandible contour.[13] Similar results have been described previously by many authors (Peter and Edward, Leonard, Alanshwimmer, Heidrun Schaaf).

In our study, post-operative swelling and lip restriction was shorter with the use of lag screws as compared to miniplate, in spite of similar surgical access. Post-operative edema was evaluated by measuring the distance from the mucocutaneous junction on the lower lip to the upper border of the thyroid cartilage in the vertical axis and the distance between the two gonial angles across the chin in the transverse axis using a 2-0 silk thread, transferring the measurements to a ruler. The average of these two post-operative measurements on post-operative day 3 was subtracted from the average pre-operative values to determine the magnitude of swelling. Duration was determined as the time required for a return to the average pre-operative measurements, as determined on the designated days of follow-up.[14] The similar results were obtained by Agnihotri *et al.* The swelling and lip restriction was presumed that the greater quantity of implanted hardware and the greater amount of bone drilling required for placement of a large number of screws in the miniplate group contributed to more persistent postsurgical edema and associated functional lip restriction.[14]

Table 5: Comparison of post-operative restriction of lip movement

Presence of post-operative restriction of lip movement	Group A *n*=12 (%)		Group B *n*=12 (%)		χ^2 value	*P* value
Till 24 h	0	0	0	0	1.833	0.608#
Till 3 days	6	50	3	25		
Till 5 days	3	25	5	41.7		
Till 7 days	1	8.3	2	16.7		
Till 10 days	2	16.7	2	16.7		
Till 15 days	0	0	0	0		
Till 1 month	0	0	0	0		

#Nonsignificant differences

In our study, postoperatively, the primary stability was achieved by both groups using lag screw and miniplate in all (100%) cases. According to Agnihotri *et al.,* the primary stabilization achieved by cortical screws was greater than that achieved by miniplate fixation (100% of cases in the former and 97.5% of cases in the latter). Post-operative MMF was not required in patients who received cortical (lag) screw fixation, indicating earlier functional rehabilitation. In cases of lag screw fixation, it appears important to manipulate the jaw segments to check for instability after releasing the MMF, as recommended by Ellis and Ghali.[15] According to Ardary, the ultimate stability of screw fixation is dependent on the number of screws used, the method of screw placement, bicortical placement of screws, and the holding power of the screws; the latter is affected by the cortical bone thickness.[16] Lag screws may also be used to supplement plate fixation so as to augment the rigidity of the fixation.[17,18] Compressing fractured bone fragments against each other when performing osteosynthesis has been shown to result in greater stability of fracture repair. According to Kallela *et al.*, if stability is doubtful, it is better to remove the screw and stabilize the fracture with, for example, a miniplate instead of subjecting the patient to MMF.[8] The most crucial factor in achieving sound compression is screw angulation in the anteroposterior direction, which should be almost sagittal. There is a tendency to drill the screw canal in a lingual direction, which results in the screw bit failing to hold in the thin lingual cortical bone. When drilling is then directed in an almost sagittal plane, it is difficult to find enough bone in the buccal cortex to hold the screw head after countersinking.[19]

To achieve a rapid recovery of form and function, internal fixation surgery should meet four basic conditions: (1) Anatomic reduction of the bone fragments; (2) functionally stable fixation of the fragments; (3) preservation of the blood supply to the fragments by atraumatic operating technique; and (4) early, active, pain-free mowbilization.[14]

None of the patients had any malocclusion in both groups using lag screw and miniplate which is similar to Tiwana

Table 6: Correlation of complications and time interval between injury and treatment

Parameter	Group A *n*=12 (%)				Group B *n*=12 (%)			
	Wound dehiscence	Wound discharge	Stability	Infection	Wound dehiscence	Wound discharge	Stability	Infection
At 24 h	0 (0)	0 (0)	12 (100)	0 (0)	0 (0)	0 (0)	12 (100)	0 (0)
At 3 days	0 (0)	0 (0)	12 (100)	0 (0)	0 (0)	0 (0)	12 (100)	0 (0)
At 5 days	0 (0)	0 (0)	12 (100)	0 (0)	0 (0)	0 (0)	12 (100)	0 (0)
At 7 days	0 (0)	0 (0)	12 (100)	0 (0)	0 (0)	0 (0)	12 (100)	0 (0)
At 10 days	0 (0)	0 (0)	12 (100)	0 (0)	0 (0)	0 (0)	12 (100)	0 (0)
At 15 days	0 (0)	0 (0)	12 (100)	0 (0)	0 (0)	0 (0)	12 (100)	0 (0)
At 1 month	0 (0)	0 (0)	12 (100)	0 (0)	0 (0)	0 (0)	12 (100)	0 (0)
At 3 months	0 (0)	1 (8.3)	12 (100)	1 (8.3)	0 (0)	1 (8.3)	12 (100)	1 (8.3)
At 6 months	0 (0)	0 (0)	12 (100)	0 (0)	0 (0)	0 (0)	12 (100)	0 (0)

et al.[20] Hany A. Emam *et al.*[21], observed complication in their study of lag screws was a case of malocclusion in 1 patient. It was managed simply by occlusal adjustment, which was also used by Kuriakose et al and Tuovinen *et al.*

One case of infection (8.3%) was seen in both groups but incidence of major complications (infection requiring hardware removal) seen in miniplate fixation. Plate was removed, curettage was done, and oral antibiotics were advised. In contrast, minor complications occurred in 1 case with use of lag screws which required only antibiotics. The incidence of post-operative infection noted in our study is similar to 6.1% as described by Iizuka *et al.*,[22] and Rosenberg *et al.*[23] recommended the removal of titanium plates in case of infection at fracture site. The study of Tuovinen *et al.*[24] who determined the incidence of infection-related plate removal to be 3.6%. However, all the post-operative complications in the lag screw group were minor and resolved without any aggressive management. Possible reasons for infection in the symphyseal region could be pre-existing subclinical infection, loose implant, foreign body reaction, inappropriate sterilization, poor host defense, and poor oral hygiene.

Another common complication, wound dehiscence which occurred usually early, 6-10 days after surgery. Dehiscence can be caused by many factors, including poor closure during surgery, smoking, trauma, and infection. Why there was a difference between the plate and lag screw groups is curious. In our study, there was no wound dehiscence seen in both groups but after 2½ months of surgery wound dehiscence and wound discharge was seen in both groups due to infection. In Group A (lag screw), only antibiotics were required but Group B (miniplate) required plate removal. Agnihotri *et al.*, analyzing wound dehiscence, only four patients in the cortical (lag) screw group developed this problem, and they did not observe this complication in the group treated with miniplates. The probable contributing factors could be inadequate muscle approximation during closure, pre-existing mucosal tear, poor oral hygiene, and delayed treatment. Resolution was obtained by irrigation with normal saline followed by placement of an adhesive elastic bandage over the chin. Unlike Cawood who encountered 12% wound dehiscence with miniplate fixation.

Champy *et al.*[25] reported an incidence of 0.5% for delayed union and nonunion in patients treated with small plate osteosynthesis. In contrast, we did not experience the above problems in our patients. The single patient in the miniplate group who needed supplemental MMF also had a clinically stable union by 6 weeks.

Assael[26] concluded that lag screw fixation of symphyseal fractures had a particularly high rate of technique related failures. Improper or inadequate counter-sinking was the chief reason for fractures of the outer cortex or distraction of the fracture when the screw was tightened. Even though the time required for lag screw fixation was high in their series, adherence to a sound clinical technique could be the reason for not having experienced technique-related failures.

CONCLUSION

The choice of suitable osteosynthesis material is an integral part of a treatment plan. Although the sample size is less, the results of our study suggest that there were no major differences in stability with lag screw and miniplates. Lag screws have the added advantage of achieving interfragmentary compression and stability with a minimum of implant material. The lag screw principle offers the advantages of fixation using minimal hardware, functional stability, is associated with minimal inflammatory complications and functional restriction, and has a lower incidence of infection when considering the treatment of linear, non-comminuted symphyseal region fractures. The procedure, however, requires more skill and expertise. This recommendation is not complete in itself, as the study is limited by the number of patients evaluated. Our observations therefore require validation with a larger sample size.

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