Masticatory Efficiency of Fracture Mandible after Osteosynthesis with 2 mm Conventional and Locking Miniplates: A Comparative Study

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ABSTRACT

Aim: To evaluate and compare the effectiveness of locking vs conventional 2.0 mm titanium miniplate in the fixation of mandibular fractures and to compare masticatory efficiency.

Materials and methods: In this study, 30 patients were selected and randomly divided into two groups (I and II). Both groups I and II consisted of 15 patients who underwent mandibular osteosynthesis using locking and conventional (non-locking) 2-mm miniplates, respectively. Postoperative follow-up was done at first, second, fourth week, and at third month for radiological and clinical assessment of all the patients.

Results: In this study, a statistically insignificant result was found in the following parameters: pain, swelling, paresthesia, infection, hardware failure, and postoperative occlusal bite forces. An increase in bite force is recorded at each follow-up (first, second, fourth week, and at third month) for both the groups. When occlusal bite forces were compared, group I showed greater mean bite force than group II at each follow-up, however, the results were statistically insignificant (p value > 0.05).

Conclusion: This study concludes that both locking and conventional miniplates are equally effective in withstanding masticatory load, with locking plates/screw system having added advantage of higher initial stability and stiffness thereby minimizing the duration of IMF. Locking miniplates system was found to have less infection and hardware failure.

Clinical significance: In this study, locking plate group was found to be clinically superior because of ease of handling, higher initial stability, and stiffness, hence minimizing the total duration and had less infection and failure.

Keywords: Conventional miniplates, Locking miniplates, Mandible fracture, Mandibular osteosynthesis, Occlusal bite forces.

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INTRODUCTION

Mandibular fractures are one of the most common fractures of the maxillofacial region. Road traffic accidents and physical assaults are reported to be the leading causes of mandible fractures.¹ Rigid internal fixation is one of the most acceptable treatment modality in mandibular fracture management. It provides adequate anatomic reduction and acceptable occlusion without an absolute requirement of intermaxillary fixation. It also reduces the chances of postoperative displacement of fracture segments facilitating early return to normal function.² Champy and his associates introduced the noncompressive miniplate fixation system, which has better results than a compressive rigid fixation system. For achieving better healing, reducing wound dehiscence and infection, miniplate fixation must be performed immediately after the injury.³ However, few literatures suggest that miniplate osteosynthesis, either early or delayed, produces similar complications.⁴ Bone plating system has been refined overtime to provide stable fixation to mandible fractures. In the present scenario, alterations in miniplates design like locking plate/screw system have been developed.⁵ Conventional miniplate has a major drawback, as it must be perfectly adapted to the underlying bone to prevent changes in the alignment of fracture segments and change in occlusal relationship.⁶

There has been a lot of research regarding the shape, size, number, and biomechanics of plate and screw system to improve surgical outcomes. Locking plates system is different from other systems, as its screws lock to the plate by the second thread under the head of the screws. These plates work as internal fixators which gains stability by locking the screw to the plate.⁶ Another advantage

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is that the meticulous adaptation of the plate to the underlying bone is not critical; therefore, minimal changes are produced in the alignment of fracture segments and occlusion during screw tightening.⁷

Every new technique has its advantages as well as disadvantages. Thus, it is necessary to evaluate this system to throw light on all its characteristics so that they may be properly applied in clinical

situations. Bite force is a reliable indicator through which the actual mandibular function and the masticatory efficiency of the patient can be measured.

This study aims to evaluate the effectiveness of locking a 2.0-mm titanium plate in comparison to the conventional 2.0-mm titanium plate in fixation of mandible fracture and also to determine the difference in postoperative bite forces in mandible fractures patients managed with both the systems.

MATERIALS AND METHODS

In this study, 30 patients were selected from the outpatient department of oral and maxillofacial surgery unit and then randomly divided into two groups (I and II). Both groups I and II consisted of 15 patients each, who underwent mandibular osteosynthesis using locking and conventional (nonlocking) 2 mm miniplates, respectively. The inclusion criteria were noncomminuted and noninfected fractures of the symphysis, parasymphysis, body, and angle region of the mandible, and exclusion criteria are fractures associated with condyle, coronoid process, ramus of the mandible, and also medically compromised patients.

Surgical Procedure

After the routine clinical and radiological examination protocol, the diagnosis was made and routine blood investigations were performed (Fig. 1). All patients gave their consent to participate in this study. During the surgery, the fracture site was exposed by intraoral approach or extraoral oral approach or through existing laceration according to the condition (Fig. 2). Following exposure and reduction in the fracture fragments, intraoperative intermaxillary fixation was done with Erich arch bar and 24-gauge stainless steel wire to achieve proper occlusion. Two miniplates were used at both symphysis and parasymphysis region, one at the inferior border and other at the superior border, and for body and angle region only one miniplate was used. Following surgery, antibiotics and analgesics were prescribed for 7 days. The patients of both the groups were followed up at postoperative interval of

first week, second week, fourth week, and third month to assess radiological and clinical evidence of healing (Fig. 3).

The thickness of the plate was kept at 2 mm, and four-hole titanium miniplates with bar was preferred with screws of 6 mm. The screws for the locking plate were 2 mm longer than the conventional screws, wherein the first 2 mm of these screws lock the miniplate. The surgical technique for the application of both the locking and the conventional 2.0 mm miniplate system were the same, as any other noncompression type of miniplate. The only exception with locking miniplates is that one should use a drill guide to make the hole at the center of the bone plate and the drill should be perpendicular to allow locking of the screw with the plate.

The patients were evaluated for fracture site, pain, swelling, occlusion, infection, paresthesia, hardware failure, duration of surgery, postoperative radiological assessment, and postoperative occlusal bite forces at each follow-up. All bite force measurements were made using an indigenous bite force sensor, which is an electromechanical device that works on strain gauge-based wheat-stone bridge. This device consists of a display unit, two probes as sensing elements, and a sensor body. The sensor is connected to a display unit, with measurements ranging from 0 to 2,500 N. All measurements were recorded, while the patients were seated in an upright position, looking straight with no headrest. Biting force was recorded at the incisor region and bilaterally at the molar region by placing the probes (padded with sponge of thickness 2 mm) on the occlusal surface and instructing the patients to bite with maximum force (Fig. 4).

RESULTS

In this study, the most common injury was road traffic accident (66.7%) followed by fall (20%) and assault (13.3%) (Table 1). The number of male patients was higher, i.e., 21 (70%), when compared to females, i.e., 9 (30%), and most common age-group who underwent surgery was between 20 years and 30 years (40%) followed by 10 to 20 years (26.67%).

In the present study, fracture distribution consists of 14 parasymphysis fractures (46.67%), which accounted for the maximum number of cases followed by 8 body fractures, 4 angle fractures (13.3%), and 4 mid-symphysis fractures (13.3%) (Table 2). Preoperative occlusion was found deranged in all patients in both the groups. Postoperative normal occlusion was achieved in all patients except in three patients of group II which was managed by selective occlusal adjustments.

Postoperative pain and swelling gradually decreased in both the groups on subsequent follow-ups. There is an insignificant difference (p value > 0.05) in group I and group II at different follow-ups. Paresthesia was noted in one patient in group I which continued up to second week and gradually disappeared in further follow-ups, whereas in group II two patients presented with paresthesia up to second week, which gradually disappeared in fourth week and third-month follow-ups.

In group I, no infection and hardware failure were reported at any of the postoperative follow-ups (Table 3). In group II, one patient presented with infection and hardware failure at third month follow-up which resolved gradually after the removal of plates. There was an insignificant difference in the duration of surgery between the two groups.

Postoperative occlusal bite forces were recorded for both group I and group II, and same fracture sites were taken for comparison of bite forces in both groups. Bite forces were compared during each

Figs 1A and B: Preoperative orthopantomograph: (A) Locking (group I); (B) Conventional (group II)

Figs 2A and B: Intraoperative procedure: (A) Locking (group I); (B) Conventional (group II)

Figs 3A and B: Postoperative 3-months follow-up orthopantomograph: (A) Locking (group I); (B) conventional (group II)

follow-up at incisor and bilateral molar region. The postoperative occlusal bite forces were increased in both the groups at every region (incisor and bilateral molar region) and at each follow-up, but when occlusal bite forces were compared between the two groups, greater mean bite force was noted in group I than group II at each follow-up. However, the results were statistically insignificant as p value >0.05 (Table 4).

DISCUSSION

Michelet et al.⁸ developed the concept of miniplate osteosynthesis in the late 1960s. Champy et al. in 1976 elaborated on Michelet's work with the intraoral application of the monocortical miniplates for treatment of mandibular angle fracture.⁹ Various fixation methods have been suggested for the treatment of fractures of mandible in the existing literature. A different type of plating system was developed initially by Raveh et al.¹⁰ known as the

locking plate/screw system. Locking plates/screw system have certain advantages over the conventional system, for instance, a meticulous adaptation of the plate to the underlying bone is not needed; therefore, there are minimal changes in the alignment of fracture segments and occlusion during screw tightening. Another possible benefit of the locking system is that these plates do not hinder the underlying cortical perfusion as much as the conventional plates that compress the inner surface of the bone plate to cortical bone.¹¹ This property of the locking plate/screw system minimizes inflammatory complications which may lead to loosening of hardware.¹² The locking system also provides greater stability when compared to the conventional miniplate system.¹³

Plate adaptation is critical in the case of conventional plates as compared to the locking plate/screw system. In the locking plate/screw system, the drill guide is used to "center" the drill hole at the center of the bone plate to achieve proper screw locking to plate.¹⁴

In this study, road traffic accidents were found to be responsible for the majority of the fractures, i.e., 20 patients (66.67%), which correlates with the other similar studies by Rowe and Killey,¹⁵ Scolozzi et al.,¹⁶ Gabrielli et al.,¹⁷ and Sai Krishna et al.¹⁸ Other reported causes for the injury are assaults, falls, sports, and industrial accidents.

In the present study, the number of male patients was higher (70%) than the number of female patients (20%), which was as per the study of Ellis et al.,² Gabrielli et al.,¹⁷ and Collins et al.¹⁹ demonstrated the high incidence of facial trauma in males. The predominance of mandible fractures in men is a relatively constant finding in most studies. In this study, para symphysis region was the most common site of fracture comprising of 46.67% of all the fracture sites followed by the fracture of body of mandible (23.33%), and this fracture distribution pattern correlates with the studies of Sai Krishna et al.,¹⁸ Collins et al.,¹⁹ and Prabhakar et al.²⁰

Restoration of occlusion is one of the most important goals in the management of maxillofacial trauma cases. In the present study, preoperative occlusion was found to be deranged in all the patients of both the groups. Postoperatively, all the patients of both the groups had satisfactory occlusion except in three patients of nonlocking group (group II), which was later managed by selective occlusal adjustments. A study by Ali et al.²¹ showed mild occlusal discrepancy in one patient (6.7%) of the locking group and 2 patients (13.3%) of the conventional group. Postoperative pain

Figs 4A and B: (A) Bite force measuring device; (B) Measuring of bite force intraorally

Table 1: Etiological percentage distribution of mandibular fractures in study subjects

Etiology	No. of patients	Percentage
RTA	20	66.67
Fall	6	20
Assault	4	13.3
Total	30	100

Table 2: Site-wise distribution of mandibular fractures

Fracture site	No. of patients with fractures	Percentage of patients with fractures
Symphysis	4	13.33
Parasymphysis	14	46.67
Body alone	8	26.67
Angle alone	4	13.33
Total	30	100

Table 3: Comparison of hardware failure in group I and group II

Follow-up period (time interval)	Group I (n = 15)			Group II (n = 15)			Significance of difference	
	Hardware failure		% of patients with hardware failure	Hardware failure		% of patients with hardware failure	χ^2	p
	Present	Absent		Present	Absent			
1 Week	0	15	0	0	15	0	–	–
2 Weeks	0	15	0	0	15	0	–	–
4 Weeks	0	15	0	0	15	0	–	–
3 Months	0	15	0	1	14	6.66	1.017	0.30

and swelling gradually decreased in both groups on subsequent follow-ups, and the results were statistically insignificant (p value > 0.05) when compared between the groups.

In group I, no infection was reported in all the patients during the follow-up period. In group II, one patient (6.66%) reported with infection at third month follow-up who presented with extraoral sinus and pus discharge near the fracture site. Pus culture and sensitivity test were done, and specific antibiotic therapy was started. After antibiotic therapy, improvement was seen, and pus discharge ceased. In this study, the meantime for duration of surgery for locking group was 50 minutes and non-locking group was 58 minutes (from giving local anesthesia till completion of suturing). Overall, there was an insignificant difference between group I and group II for the duration of surgery.

In this study, an increase in postoperative occlusal bite force was observed in the incisor, left molar, and right molar of groups I and II in the follow-ups done on the first, second, fourth week, and third month. On comparison of the occlusal bite forces between the groups, group I showed greater mean bite force at each follow-up

when compared to group II, but these results were statistically insignificant as p value > 0.05 , and this result was similar to the result of a study conducted by Anand et al.²² These findings are also concurrent with the results of Rastogi et al.²³ who concluded that there is no statistically significant difference between locking plates and conventional plates with respect to the mean bite force (p value > 0.05).

CONCLUSION

This study concludes that both locking and conventional miniplate are equally effective (statistically insignificant difference) in withstanding masticatory load with locking plates/screw system having added advantage of higher initial stability and stiffness than conventional plate thereby minimizing the duration of IMF. Locking miniplates system was found to have less infection and hardware failure than conventional miniplate and precise adaptation of locking miniplate is not critically important. Studies with a larger sample size and more study duration are necessary

Table 4: Table showing the comparison between postoperative occlusal bite forces between group I (locking) and group II (conventional)

Follow-up	Region	Group	Mean $\pm$ SD	t value	p value
1st week	Incisor	I	54.13 $\pm$ 14.21	0.64	0.53
		II	50.87 $\pm$ 13.67		
	Left molar	I	149.73 $\pm$ 36.31	0.42	0.67
		II	144.13 $\pm$ 35.82		
	Right molar	I	154.53 $\pm$ 32.60	0.40	0.69
		II	149.47 $\pm$ 36.03		
2nd week	Incisor	I	71.80 $\pm$ 13.72	0.77	0.44
		II	68.80 $\pm$ 13.26		
	Left molar	I	174.67 $\pm$ 39.27	1.77	0.08
		II	150.73 $\pm$ 34.52		
	Right molar	I	171.53 $\pm$ 35.17	0.35	0.72
		II	166.80 $\pm$ 37.72		
4th week	Incisor	I	110.60 $\pm$ 14.67	0.43	0.66
		II	108.40 $\pm$ 13.07		
	Left molar	I	271.73 $\pm$ 33.43	1.47	0.15
		II	254.40 $\pm$ 31.10		
	Right molar	I	279.00 $\pm$ 24.77	0.26	0.79
		II	276.13 $\pm$ 35.29		
3rd month	Incisor	I	130.06 $\pm$ 10.53	0.24	0.82
		II	129.26 $\pm$ 7.84		
	Left molar	I	337.47 $\pm$ 10.25	0.79	0.43
		II	334.53 $\pm$ 10.04		
	Right molar	I	334.93 $\pm$ 11.45	0.30	0.76
		II	333.60 $\pm$ 12.33		

to corroborate the findings of the present study for their wide use in clinical practice.

CLINICAL SIGNIFICANCE

In this study, locking plate group was found to be clinically more superior because of ease to handle (no need of adaptation), its higher initial stability, and stiffness than conventional plate, thereby minimizing the total time duration and less infection and failure rate.

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