Original Article

A comparative study on evaluation of role of 1.5 mm microplates and 2.0 mm standard miniplates in management of mandibular fractures using bite force as indicator of recommendation

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ABSTRACT

Aims and Objectives: To compare the maximum voluntary bite force generated at different periods during mandibular fracture healing using miniplates and microplates as means of rigid internal fixation. **Materials and Methods:** Maximum voluntary bite force was recorded in healthy young individuals of different age group from either gender. Patients suffering from symphyseal and parasymphyseal and body fractures were selected and randomly treated using miniplate and microplate osteosynthesis by open reduction and rigid internal fixation. Postoperative bite forces at intervals of 1st, 2nd, 4th, and 6th week were recorded and compared with control group. **Observations and Results:** It was noticed that bite forces were significantly reduced in the study groups in comparison to control group and at different intervals of treatment. There was a progressive improvement in the bite force with passage of time. There was no statistical significance in the observed bite force in both the study groups at different intervals of assessment. **Conclusion:** 1.5 mm microplates provide adequate stability comparable to miniplates for the treatment of fractured mandible and should be preferred over miniplates. We further suggest that bite forces should be considered for the assessment of clinical union of bone as well as studies pertaining to selection of hardware for rigid internal fixation.

Key words: Healing of fractures, metal leaching, microplates, rigid internal fixation, voluntary bite force

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Access this article online

Quick Response Code:

Website: www.njms.in

DOI: 10.4103/0975-5950.196128

How to cite this article: Ahmed SS, Rehman SA, Ansari MK, Khan AA, Farooq O, Khan AH. A comparative study on evaluation of role of 1.5 mm microplates and 2.0 mm standard miniplates in management of mandibular fractures using bite force as indicator of recommendation. Natl J Maxillofac Surg 2016;7:39-44.

Introduction

Fractures of mandible are commonly treated by rigid internal fixation using 2.0 miniplates to restore the normal form and function. With time, an evolution in size and shape of fixation devices has taken place. Michelet *et al*.[1] in 1973 introduced the miniplate osteosynthesis and Champy *et al*.[2] further developed Champy's concept and described ideal lines of osteosynthesis for placement and fixation of plates in various regions for mandibular fracture. These miniplates are available in different designs, sizes, shapes, number of wholes, and they are fixed by screws of different sizes. There are reports which indicate that leaching of metal takes place in the adjacent tissues of plates as well as peripheral organs after osteosynthesis.[3-6] Thus, the size of hardware should be optimized not only to resist the masticatory stresses, to provide sufficient stability to the bone segments and restoration of normal masticatory function but also to leaching of metal.

Evans *et al*.[7] performed their studies and suggested the role of miniplates and microplates in treatment of mandibular and midfacial fractures.

Feller *et al*.[8] performed biomechanical studies and suggested that a combination of miniplate and microplate provided sufficient stability for complication-free healing of fractures. Gupta *et al*.[9] studied the bite forces with such combination and confirmed the findings of the Feller. This was, in fact, an effort to advocate the minimum use of hardware. This effort must have minimized the metal leaching also.

Available data indicate that bite forces are reduced in traumatized mandible and biting, and masticatory forces are severely compromised as the tissue environment is significantly altered,[10,11] thus affecting the biting force. In such situation, a combination of 1.5 mm microplates may be adequate to bear the masticatory stresses and must provide sufficient stability as tensile forces at which permanent deformation takes place in these plates are much higher than the bite forces to which these plates are exposed in the healing phase of bone.

On the basis of available data of masticatory forces in fractured mandible, we gave a null hypothesis that microplates, if used in mandibular fractures would be sufficient to provide stability to fractured bone and resist masticatory forces.

Aims and objectives

The aims and objectives of the study were to compare bite forces generated in patients treated with 2.0 mm miniplates or 1.5 mm microplates in symphyseal and parasymphyseal fractures at postoperative interval of 1 week, 2 weeks, 4 weeks, and 6 weeks and to compare the efficacy of these plates in the treatment of mandibular fractures.

Materials and Methods

Study sample collection

The study was approved by the Institutional Ethical Committee and was conducted at Department of Oral and Maxillofacial Surgery, Dr. Ziauddin Ahmad Dental College, Aligarh Muslim University, Aligarh. To perform the study, data for maximum voluntary bite force in control group were collected on young volunteers of different age group among which were dental students and employees of dental college. The exclusion criteria included volunteers which were (1) partially or completely edentulous, (2) medically compromised, and (3) with preexisting dental pain or myofascial pain.

The patients in study Group I were treated by open reduction and rigid internal fixation (ORIF) using 1.5 mm microplates and in Group II using 2.0 miniplates. Both the plates with screws were supplied by M/S Loyal Surgicals, Mumbai, for the purpose of the study.

Bite force recording equipment

A bite force recorder [Figure 1] was developed at Division of Ergonomics, Department of Mechanical Engineering, Aligarh Muslim University, Aligarh, which consisted of a transducer based on Wheatstone bridge which worked as pressure sensing device, a digital electronic display, and an adjustable knob for adjusting zero of the display. The equipment consisted of metallic fork covered with disposable cushioned adhesive tape which was meant for force application. The equipment was connected to 250V electrical supply for charging backup of equipment. The consistency and accuracy of bite force were reaffirmed by doing detailed laboratory and clinical testing on fifty individuals.

Figure 1: Bite force recorder with biting fork

The participants in the study were fully made aware of bite force recording equipment and then mechanism of recording. The pressure fork was covered with sterile adhesive tape which was soft and had cushioning property and gave a feeling of comfort on biting on it. The fork was covered with sterile gloves for further sterility. After every patient, the fork was cleaned, adhesive tape changed, and then covered in sterile gloves. The patients were asked to bite on the fork from anterior as well as left and right molar teeth. The findings were recorded in specially designed format, and results were statistically analyzed.

Data collection

The bite force was recorded by asking the participant to bite on fork by maximum pressure from front teeth and by occluding the molars. Each volunteer/patient was asked to sit erect and relaxed keeping the head in Frankfort horizontal plane parallel to ground floor. Three successive readings were taken on either side after giving a rest of 10 s on each side and highest value biting force was considered as maximum bite force.

Study groups

For analyzing the data, three study groups were made:

- Control: Healthy young volunteers
- Group I: Patients treated with miniplate for symphyseal/parasymphyseal/body fractures
- Group II: Patients treated with microplates for symphyseal/parasymphyseal/body fractures.

Observations and Results

The individuals of control group underwent for single stage data collection while the patients of Group I and II were called for follow-up at postoperative interval of end of 1st, 2nd, 4th, and 6th week. All the patients were treated by the same surgeon and treated according to clinical situation by intra-/extra-oral open reduction and rigid fixation using miniplates or microplates [Figure 2a-c].

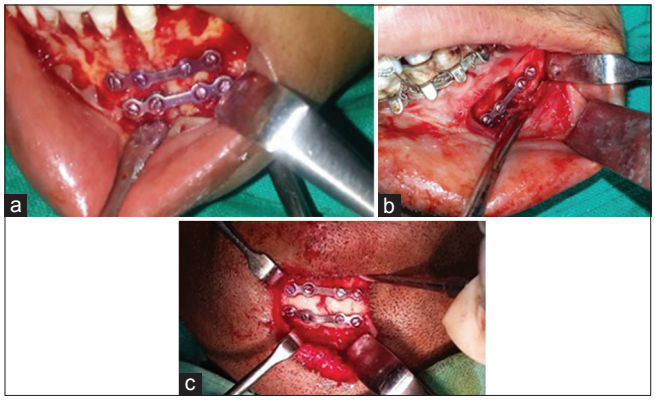

Figure 2: (a) Open reduction and rigid internal fixation in parasymphysis region. (b) Open reduction and rigid internal fixation in the body region. (c) Open reduction and rigid internal fixation in parasymphysis by extraoral route

To prevent the bias, every alternate patient was treated by miniplates and microplates.

Thirty healthy volunteers in control group and forty patients, with twenty patients in each study group (Group I and Group II), were included in the study. The average age of volunteers in control group was 26.3 years (age range, 18–34), in patients of Group I was 30.6 years (age range, 18–55 years), in Group II was 30.7 years (age range, 19–55 years). Table 1 shows gender-wise distribution of patients and Table 2 shows site-wise distribution of cases operated in each study group and Table 3 shows average bite force observed in volunteers under control group.

Table 4 reveals the values of preoperative bite forces with their standard deviation in study Groups I and II and Table 5a and b shows week-wise changes in bite force in study groups.

Statistical data

The data were analyzed using online software GraphPad software Quick Calcs from website: http://www.graphpad.com/quickcalcs/ttest2/. Table 6 shows *P* values of bite force in anterior and left and right posterior region. Table 7a-c shows postoperative

Table 1: Gender-wise distribution of patients

Group	Gender		Total
	Male	Female	
Group I (microplates)	16	4	20
Group II (miniplates)	17	3	20
Total	33	7	40

Table 2: Site-wise distribution of patients

Site	Group I	Group II	Total (%)
Mid symphysis	3	4	7 (17)
Parasymphysis	11	10	21 (53)
Body	6	6	12 (30)
Total	20	20	40

Table 3: Mean bite force in control group

Group	Right molar region	Central incisor region	Left molar region
Control	50.6 kg	16.3 kg	52.1 kg

Table 4: Preoperative bite forces in study groups

Group	Average bite force ± SD		
	Incisor region	Right molar	Left molar
Group I	1.81 ± 0.55	5.4 ± 0.73	5.6 ± 0.65
Group II	2.1 ± 1.01	4.41 ± 0.73	4.7 ± 0.77

SD: Standard deviation

Table 5a: Week-wise changes in bite force in study Group I

Group	Week-wise details	Bite force in different region (in kg)		
		Right molar region	Central incisor region	Left molar region
Group I (microplates)	End of 1st week	8.3	2.5	8.9
	End of 2nd week	11.4	3.8	11.6
	End of 4th week	20.8	10.7	19.5
	End of 6th week	30.4	12.8	31.1

Table 5b: Week-wise changes in bite force in study Group II

Group	Week-wise details	Bite force in different region (in kg)		
		Right molar region	Central incisor region	Left molar region
Group II (miniplates)	End of 1st week	8.1	2.8	9.7
	End of 2nd week	11.7	4.0	12.0
	End of 4th week	21.3	10.6	20.2
	End of 6th week	30.4	12.5	31.3

Table 6: Preoperative bite force in study groups

Region	Mean ± SD		*t*	*P*
	Group I	Group II		
Central incisor	1.81 ± 0.55	2.1 ± 1.01	1.1277	0.2665*
Molar left side	5.6 ± 0.73	4.7 ± 0.77	0.0973	0.0002**
Molar right side	5.4 ± 0.73	4.41 ± 0.73	4.2886	0.01**

*Statistically not significant, **Highly significant. SD: standard deviation

P values of bite force observed in anterior and left and right posterior region of study groups at different intervals.

The bite forces in different study groups after rigid fixation and different weeks of recovery were recorded. It was noticed that the incisor bite force was significantly reduced in the first 6 weeks after ORIF when it was compared with the patients after the 6th postoperative week and the controls ($P < 0.001$). In week 1, the incisor bite force was 2.5 and 2.8 kg, respectively, in Group I and Group II which raised to 12.8 and 12.5 in incisor region.

In the molar region, the bite force in Group I was 30.7 and 30.8 kg at the end of 6th postoperative week, which was 8.3 and 8.9 kg at the end of 1st postoperative week in right and left molar region, respectively [Figure 3].

In Group II, the bite force in molar region was 30.4 and 31.7 kg at the end of 6th postoperative week, which was 9.3 and 9.7 kg at the end of 1st postoperative week in right and left molar region, respectively.

Thus, a significant reduction in molar bite force occurred in patients of each group and in the region of interest when compared with 6 week postoperative bite force and with the control values ($P < 0.001$). There was a progressive improvement in bite forces with elapse of time which indicated the repair of soft tissues as well as healing of the bone.

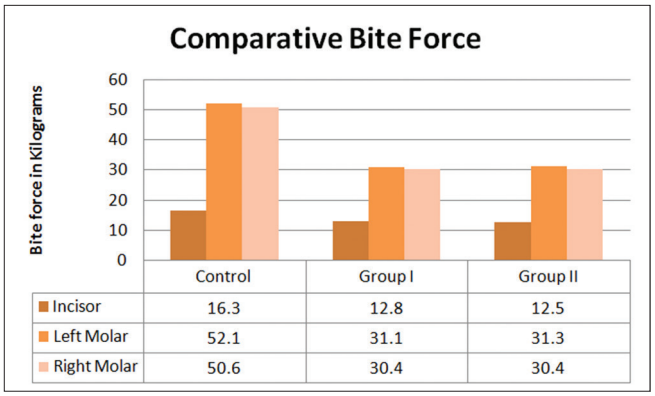

Figure 3: Bar diagram showing maximum voluntary bite force in control group, and 6 weeks postoperative bite forces in Group I and Group II in incisor, left molar, and right molar region

Complications

Within the two study groups, of twenty patients each, who were treated according to Champy's principle and by ORIF. Overall complications were recorded in five patients (12.5%) in both study groups. One patient required revision surgery, two patients had occlusal disturbance, one had abscess in fracture line, and one had dehiscence. Altogether 35 patients (87.5%) were treated successfully without any complication. The occlusal disturbance was corrected by occlusal grinding; abscess was simply managed by standard methods treating infection and did not require plate removal. However, the case in which there was wound dehiscence exposing plate was treated by plate removal followed by intermaxillary fixation; the overall success may be said as 38/40, i.e., 95%. Hence, it may be said that overall success rate was 95%. Hypoesthesia was not seen in Group I cases whereas it was seen in only case in Group II. Disturbed occlusion was seen in Group II and none in Group I. Majority of the complications were managed by routine OPD procedure.

Table 7a: Week-wise changes in incisor bite force

Period of follow-up	Mean ± SD		*t*	*P*
	Group I	Group II		
Preoperative	1.81 ± 0.55	2.1 ± 1.01	1.1277	0.2665*
1 week	2.5 ± 0.66	2.8 ± 0.83	1.2652	0.2135*
15 days	3.8 ± 0.65	4.0 ± 1.58	0.6037	0.6037*
4th week	10.7 ± 1.64	10.6 ± 1.00	0.2328	0.8171*
6th week	12.8 ± 1.46	12.5 ± 1.09	0.7364	0.4660*

*Not significant. SD: Standard deviation

Table 7b: Week wise changes in molar bite force (left side)

Period of follow-up	Mean ± SD		*t*	*P*
	Group I	Group II		
Preoperative	5.6 ± 0.73	4.7 ± 0.77	0.0973	0.0002**
1 week	8.9 ± 1.27	9.7 ± 1.63	1.7314	0.0915*
15 days	11.6 ± 0.73	12.0 ± 1.16	1.3052	0.1997*
4th week	19.5 ± 1.19	20.2 ± 1.58	1.5827	<0.1218*
6th week	31.1 ± 1.56	31.3 ± 1.27	0.4446	0.6591*

**Highly significant, *Not significant. SD: Standard deviation

Table 7c: Week-wise changes in molar bite force (right side)

Period of follow-up	Mean ± SD		*t*	*P*
	Group I	Group II		
Preoperative	5.4 ± 0.73	4.41 ± 0.73	4.2886	0.0001**
1 week	8.3 ± 0.93	8.1 ± 1.32	0.5539	0.5829*
15 days	11.4 ± 0.71	11.7 ± 1.24	0.9389	0.3537*
4th week	20.8 ± 1.20	21.3 ± 2.16	0.9049	0.3712*
6th week	30.4 ± 1.47	30.4 ± 1.2	0.0000	1.0000*

**Highly significant, *Not significant. SD: Standard deviation

Discussion

The measurement of bite forces has been remained a matter of interest among researchers. However, there is inconsistency in the findings and maximum value of bite forces presented by different authors.[9,11-13] The reasons of this variation may be many. The device used to record the bite force, its sensitivity, comfort of the volunteer, and psychological state of volunteer. In addition, genetic and ethnic, food habits, and geographical factors may be also responsible for this variation. Individual neuromuscular mechanism may itself be also an important factor for this difference.[14,15]

There is individual variation in masticatory forces or bite force. Maximum bite force is the greatest force that an individual can generate by voluntary clenching of teeth in the occlusal position. We measured the maximum bite in young men and women healthy volunteers which was taken as control to compare with patients in the study group. We found that the bite forces in control group in incisor region were 16.3 kg, right molar region 50.6 kg, and left molar region were 52.1 kg. These forces are generated due to interaction of masticatory muscle forces and must be overcome by desired treatment.

In a similar study, Gupta *et al*.[7] found that voluntary bite force in a healthy adult was on the order of 15.4 kp in the incisor and 48.3 and 49.2 kp in the left and right molar regions, respectively. Our findings are much closure to findings of Gupta *et al*.[7] which may be due to volunteers belong to same geographical location and had similar food habits.

In our study, it was noticed that preoperative forces were highly significant in molar regions of study group [Table 4]. These values may be just by chance and practically bear no clinical significance. However, the bite forces progressively increased in each study group, and their comparative value remained insignificant throughout the phase of recovery [Table 7a-c]. However, by the end of 6th weeks, patients in either group regained 60% in molar region and 75% in anterior region. This pattern of recovery can be attributed to psychological state of patient as if they themselves avoid applying heavy chewing forces due to fear of refracture of jaw or any disturbance in normal healing. This can be also inferred that 60% of maximum bite force is usually sufficient for comfortable chewing.

It has been suggested that the amount of force used during functional activity is much less than the voluntary bite force. It is further reduced in trauma affairs. Therefore, the fixation requirements based on the maximum voluntary bite force in noninjured participants may be more there for the monocortical fixation has been used successfully.[8,9]

The reason for reduced bite force after treatment by open reduction and rigid fixation is injury to not only bone but also investing periosteum and associated muscles in the adjacent area. Formation of hematoma in the region itself may affect the movement. In addition, surgical trauma to muscles and periosteum may also restrict the normal function of the body until healing has taken place. Intra- or extra-oral placement of fixation hardware necessitates the placement of incision, reflection of mucoperiosteal flap and in selected cases incising the muscle fibers as well. All these reasons of trauma are responsible for compromised masticatory function until healing is completed.

Our findings are important to recommend the use of 1.5 system microplates for treatment of mandibular fractures. As there is no significant difference in the bite force generated when microplates are used, in comparison to miniplates, and they provide adequate stability to fractured segment, their use may be recommended for routine use. Another important aspect is minimization of metal leaching in the adjacent tissues. This is perhaps first study, in which bite forces have been compared with miniplate and microplate. On the basis of our findings, we recommend that microplates should be preferably used for mandibular fracture.

Kumar *et al*.[16] observed that patients treated with locking plate/screw system postoperatively generated more bite force compared to those treated with conventional miniplate screw system. However, they have not highlighted the significance of their findings in statistical terms. The increase in bite force may be due to mechanical advantage provided by locking plate.

On the basis of available data, we are able to demonstrate that major complications were rare (5%) using microplate and miniplate osteosynthesis. This furthers proves that microplates are equally good as miniplates as far as linear fractures are concerned. However, for comminuted fractures, more rigid plates should be used.

Conclusion

On the basis of our study we conclude that 1.5 mm microplates are rigid enough to provide adequate stability to the fractured segments which is comparable to miniplates in the isolated fractures of mandible and should be preferred over miniplates. In addition the bite forces should be considered for the assessment of clinical union of bone as well as studies pertaining to selection of hardware for rigid internal fixation.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

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