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Comparative Evaluation of Bite Forces in Patients with Mandibular Fractures Treated With Microplates and Miniplates

[1]Dr.B.Pavan Kumar, Professor & HOD, Department of Oral and Maxillofacial Surgery, Kamineni Institute of Dental Sciences, Nalgonda, India.

[2]Dr.M.Manoj Srikanth, Post Graduate Trainee, Department of Oral and Maxillofacial Surgery, Kamineni Institute of Dental Sciences, Nalgonda, India.

[3]Dr.V.Venkatesh, Professor, Department of Oral and Maxillofacial Surgery, Kamineni Institute of Dental Sciences, Nalgonda, India.

[4]Dr. Vuyyuru Vidya Devi, Assistant Professor, Department of Oral and Maxillofacial Surgery, Kamineni Institute of Dental Sciences, Nalgonda, India.

Corresponding Author: Dr. Vuyyuru Vidya Devi, Assistant Professor, Department of Oral and Maxillofacial Surgery, Kamineni Institute of Dental Sciences, Nalgonda, India.

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Abstract

Aim: To compare bite forces generated in patients treated with miniplates and microplates in mandibular fractures at different postoperative interval and to compare the efficacy and functional stability of these plates in the treatment of isolated mandibular fractures.

Materials & Methods: Twenty patients were selected with isolated mandibular fractures and divided into two groups with each of ten patients (study group I and II) and treated with miniplate and microplate osteosynthesis by open reduction and rigid internal fixation. Ten healthy young individuals were selected, as control, of different age group of either gender for recording the maximum voluntary bite forces. The bite forces of both the study groups was recorded pre operatively and post operatively at each follow up using bite force tranducer and compared with the control group. The patients were also assessed for complications such as infection and wound dehiscence that might interfere with the overall success of osteosynthesis.

Observation and Results: A statistically significant increase in the bite force of incisors and right and left molar region was noticed in both the study groups compared with the pre operative bite forces. However, there was no statistically significant difference observed in the bite forces of both the study groups at different follow up period. There was a progressive increase in the bite forces as each follow up which suggested a satisfactory healing of the bone. Post operative infection was noticed in 1 patient (10%) in each of the study group which was eventually resolved by use of antibiotics.

Conclusion: The use of microplate osteosynthesis is stable enough to withstand the masticatory forces generated during the healing phase of the fractured bone and can be effectively preferred in the place of miniplates for fixation of isolated mandibular fractures.

Keywords: Bite force, Mandibular fracture, Microplates, Rigid internal fixation.

Introduction

The treatment of mandibular fractures has been in a constant state of evolution with goals to restore function and premorbid occlusion and to achieve stable osseointegration. Miniplate osteosynthesis, introduced by Michelet et al [1] in 1973 and further developed by Champy et al [2] in 1978 has become the standard treatment of mandibular fractures. 2.0 mm miniplates and reconstruction plates are commonly used to treat simple and comminuted mandible fractures. Even among miniplates, the profile, that is, the thickness of the plate increases with increase in size. However, reconstruction plates are bulky and palpable through the thin skin and the gingiva. There is limited space available in the upper half of the mandible for a higher profile miniplate, which can result in complications such as infection, wound healing problems, tooth root injuries, or mass effect problems.[3] In addition, the metal plate itself can damage the surrounding hard and soft tissues. There are reports which indicate that leaching of metal takes place in the adjacent tissues of plates as well as peripheral organs after osteosynthesis. Thus, the size of hardware should be optimized, not only to resist the masticatory stresses, but also to leaching of metal.[4,5]

A micro-fixation-system was developed with extremely tiny plates and screws to achieve adequate three-dimensional rigidity and at the same time with minimal interference with the overlying soft tissues.[6] Due to the added advantages like low profile of plates and screws, higher corrosion resistance, light weightedness and lesser toxicity, there are lesser chance of iatrogenic damages from the microplate fixation system when used for the internal fixation of maxillofacial fractures.[3]

Previously, microplates were used in non stress bearing areas such as the mid face, but recent experimental and clinical studies have shown that microplates can be used efficiently in stress-bearing areas such as mandible.[6-10] There are many studies which have shown the effect of trauma on masticatory and biting forces. In a traumatized mandible the environment of soft and hard tissue, both are affected. Thus, masticatory and biting forces are altered, and infact, significantly compromised in the new environment.[11,12] Taking this into consideration, the use of 1.2 mm microplate may be adequate to bear the masticatory stresses as tensile strength of these plates is more than the tensile strength of bone and the maximum masticatory forces developed in fractured mandible are significantly low in the healing phase. Hence microplates can be used in place of miniplates.

The present study was carried out to evaluate the bite forces of the patients with mandibular fractures and determine the rate of recovery of the bite force after treatment with 1.2 mm microplates in comparison to those treated with 2.0 mm miniplates.

Materials and Methods

Study Sample And Data Collection

The study was approved by the Institutional Ethical Committee and was conducted at Department of Oral and Maxillofacial Surgery, Kamineni Institute of Dental Sciences, Sreepuram, Narketpally, Nalgonda District. To perform the study, maximum voluntary bite force in control group was recorded from young healthy volunteers of different age group. The exclusion criteria included volunteers who were (1) partially or completely edentulous, (2) medically compromised, (3) with pre existing dental or myofascial pain and (4) with any neurologic or TMJ dysfunction. All the subjects were explained about the purpose of the study and an informed consent was obtained from them. All procedures were

non-invasive, the only risk being the dental fracture during maximum clench and risk was limited and proper care was taken to avoid any damage to the teeth.

In the study group, patients above the age of 14 years who were medically fit for general anesthesia and those giving consent for participating in the study were selected. Patients with displaced/undisplaced mandibular symphysis fractures, displaced/undisplaced, unilateral/bilateral parasymphysis, body and angle fractures were included in the study. Patients with any uncontrolled systemic diseases, ongoing chemotherapy or radiotherapy, neuromuscular disorders, edentulous patients, gross comminution of fracture or any associated midface fractures, condylar/subcondylar fractures and patients with any infection or underlying pathology at the fracture site were excluded from the study.

After pre operative evaluation of the patients, three study groups were made for analysing the data. Control group included healthy young volunteers. Group I included patients treated by open reduction and internal fixation with 2.0 mm miniplates (Figure 1) and Group II included patients treated with 1.2 mm microplates (Figure 2).

Figure 1: Parasymphysis fracture treated with 2mm miniplate system

Figure 2: Parasymphysis fracture treated with 1.2 mm microplate system

Bite Force Recording

The bite forces were recorded with a strain gauge bite force transducer made of stainless steel biting sensor of width 5×10 mm and a micro controller based digital load indicator, manufactured by Analog & Digital Instrumentation Artech Transducers Pvt. Ltd. Proper care was taken to clean the biting fork after each and every volunteer/patient to maintain sterility and prevent any cross contamination. A medium body putty was used to cover the biting sensor to avoid any damage to the strain gauge and the sensor was placed at the incisal edge of the anterior teeth for measuring anterior bite force. The subjects were asked to bite hard on the sensor and the maximum bite force readings on the meter display were recorded (Figure 3). Similarly the posterior bite force was recorded in the right and left first molar region. Three successive readings were taken on each side with an interval of one minute to avoid muscular fatigue and discrepancy of readings and highest value was considered as maximum bite force. The findings were recorded in a specially designed format, and results were statistically analyzed.

Figure 3: Recording the bite force with Bite force transducer

Observation And Results

The individuals of control group underwent single stage data collection while the patients of Group I and II were called for follow-up at postoperative interval of 1 st day, 1st week, 1st month and 3rd month. All the patients were treated by the same surgeon and treated by intra oral open

reduction and rigid internal fixation using miniplates or microplates.

Ten healthy volunteers in control group and twenty patients, with ten patients in each study group (Group I and Group II), were included in the study. The average age of volunteers in control group was 25.8 years (age range, 21–34), in patients of Group I was 27.4 years (age range, 20–35 years), in Group II was 30.3 years (age range, 18–40 years). The most common type of fracture encountered were isolated parasymphysis fractures followed by isolated angle fractures (Table 1).

Type of fracture	Group I	Group II	Total
Isolated Symphysis fracture	1	1	2
Isolated angle fractures	3	2	5
Angle with parasymphysis fracture	1	1	2
Isolated parasymphysis fracture	5	5	10
Bilateral parasymphysis Fracture	0	1	1

Table 1 : Type of fracture among study groups

The average bite force in the healthy volunteers in the incisor, right molar and left molar region was recorded as 10.3 Kg, 40.2 Kg and 42.6 Kg respectively (Table 2).

Group	Mean ± SD (in Kg)		
	Incisors	Right Molars	Left Molars
Control	10.3 ± 4.7	40.2 ± 11.7	42.6 ± 11.5

Table 2 : Mean bite force in control group

In group I and II, there is observed a steady increase in the bite force compared to the pre operative bite forces in all the region, over the 3 month follow up period (Table 3, Figure 4).

All the data was analysed using the Statistical Package for Social Sciences (SPSS) statistical analysing software. Parametric data were evaluated by Paired t-test and Wilcoxon Signed Ranks test and p value < 0.05 was considered statistically significant.

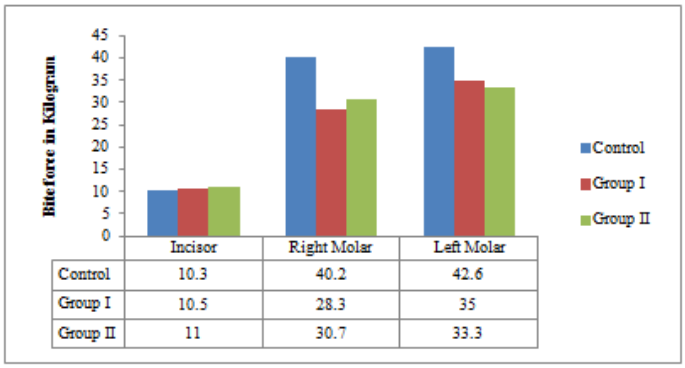
It was noticed that the incisor bite force was significantly reduced until 1st month after ORIF when it was compared with the patients after the completion of 3 months and the controls ($P < 0.001$). After the completion of 1st week, the incisor bite force was 3.5 and 3.6 Kg, respectively, in Group I and Group II which raised to 10.5 and 11.0 Kg by the end of 3 months. The average bite forces after 1st week post operatively were found to have significantly increased than that on the 1st post operative day with p value of < 0.001.

Time interval	Mean ± SD (in Kg)					
	Group I			Group II		
	Incisors	Right Molars	Left Molars	Incisors	Right Molars	Left Molars
Pre operative	2.7 ± 0.9	10.9 ± 5.1	14.7 ± 6	2.6 ± 0.9	11.6 ± 3.8	11.0 ± 5.5
1st day post operative	2.7 ± 0.8	11.7 ± 4.7	14.5 ± 5.7	2.6 ± 0.9	12.1 ± 3.8	11.1 ± 5.4
1st week post operative	3.5 ± 0.8	14.3 ± 4.0	17.9 ± 6	3.6 ± 1.0	13.9 ± 4.4	14.3 ± 5.2
1st month post operative	6.3 ± 1.4	20.5 ± 4.6	25.8 ± 6.5	7.2 ± 2.0	22.5 ± 3.5	23.3 ± 4.3
3rd month post operative	10.5 ± 1.5	28.3 ± 4.8	35.0 ± 6.0	11.0 ± 2.3	30.7 ± 2.7	33.3 ± 4.7

Table 3 : Week-wise change in bite force in study groups

The bite force in Group I was 14.3 and 17.9 Kg at the end of 1st postoperative week, which raised to 28.3 and 35.0 kg at the end of 3rd postoperative month in right and left molar region respectively. Similarly, in Group II, the bite force was increased to 30.7 and 33.3 Kg at the end of 3rd

postoperative month, which was 13.9 and 14.3 Kg at the end of 1st postoperative week in right and left molar region, respectively.



	Incisor	Right Molar	Left Molar
Control	10.3	40.2	42.6
Group I	10.5	28.3	35
Group II	11	30.7	33.3

Figure 4 : Comparison of maximum voluntary bite force in control group and study group after 3rd post operative month

Thus, a significant reduction in molar bite force occurred in patients of each group and in the region of interest when compared with the bite force after 3 months post operatively 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. There was no significant difference ($P > 0.05$) in the bite forces generated between the two groups.

Post operative infection was noticed in 1 patient (10%) in each group on 1st post operative week which was eventually resolved with the use of antibiotics. Other than that the overall complication rate was not significant in both the groups.

Discussion

Maximum bite force is the greatest force that an individual can generate by voluntary clenching of teeth in the occlusal position. There has been an inconsistency in the findings and maximum value of bite forces presented by different authors.[13,14] The reasons of this variation may be many, such as, the device used to record the bite force, its sensitivity, comfort and psychological state of volunteer, genetic and ethnic, food habits and geographical factors. Individual neuromuscular mechanism may itself be also an important factor for this difference.[15]

It has been established that biting and occlusive forces are reduced in traumatized mandible.[16] A time based assessment in the post treatment phase of biting and occlusive forces would present a real picture of masticatory function. Thus to evaluate the efficacy of microplate in mandibular fractures we concentrated first on studying the bite forces at different intervals after ORIF and then comparing them with normal healthy volunteers and inferring the outcome to determine the time taken for the bite forces to return to a normal functional range.

For this purpose, bite forces in healthy and young volunteers (Control group) were recorded using digital bite force transducer. The average bite force in the healthy volunteers in the right molar region, left molar region and the incisor region were 40.2 Kg, 42.6 Kg and 10.3 Kg respectively. In a similar study, Gupta et al.[13] found that voluntary bite force in a healthy adult was on the order of 15.4 Kg in the incisor and 48.3 and 49.2 Kg in the left and right molar regions, respectively. Rajesh K et al.[14] revealed that the maximum voluntary bite force measurement in healthy Indian individuals is of the order of 36 Kg in the molar region and 15 Kg in the incisor region. In another study by Srikanth et al.[17] the mean maximum voluntary bite force in the incisor and first molar region on the right and left side was found to be 10.66 Kg, 38.53 Kg and 40.13 Kg respectively. Our findings are in coherence with the previous studies. This may be due to similar geographic distribution and food habits.

In the present study it was observed that there was a steady increase in the bite forces in subsequent follow up periods in each study group, which indicates the ongoing

process of uncompromised bone healing. However the comparative value remained insignificant between the two study groups throughout the phase of recovery. These findings are in accordance with the findings presented in previous studies.[12-14,18]

By the end of 3 months, patients in both the groups achieved 75% of the mean healthy bite force, in the molar region and 100% in the incisor region. Although at the end of 3rd month the bite forces does not reach to normal but they are sufficient to bear the normal masticatory forces which is less than the voluntary biting forces. This pattern of recovery can be attributed to psychological state of patient as they avoid applying heavy chewing forces due to fear of refracture of jaw or any disturbance during the healing phase Since the patient is able to chew soft diet it can be inferred that early functional load needed for chewing is reached at first week of bone healing.

It has been suggested that the amount of force used during functional activity is much less than the voluntary bite force which is further reduced in trauma. The most probable reason is the protective mechanism called muscle splinting, which is relevant when a fracture occurs. Reasons for subnormal forces in mandibular fractures may be trauma to masseter and temporalis muscle intraoperatively and protective neuromuscular mechanism of masticatory system.[7,13]

Thus, we hypothesised, that the healthy voluntary bite forces which fixation systems are traditionally built to withstand, severely overestimates the clinical forces that the plating system experiences in vivo, in a fractured mandible, leading to the larger size and bulk, as in miniplate fixation.

The microplate system have been shown to possess a tensile strength of 16.44 ± 2.04 Kg and are capable of withstanding forces upto 27.02 Kg.[19] Taking the weakened bite forces in an injured mandible into consideration the capabilities of the micro plate system are seen to be adequate.

As there is no significant difference in the bite force generated when microplates are used, in comparison to miniplates, and thus evidently no difference in the rate of healing, their use may be recommended in mandibular fracture fixation. On the basis of our findings, we recommend that microplates should be preferably used for mandibular fracture due to the added advantage of smaller incision and less manipulation of soft tissue, lesser implant material and reduced chances of iatrogenic damage.

Complication rate was minimal in our study. Infection was observed in 1 patient in each group (10%), which is slightly higher than in the studies by Champy et al.[2] (3.8%), Cawood [20] (6%), Smith [21] (2.5%), and Nakamura et al [22] (1.0%). This difference is statistically insignificant because of the small number of patients in the present study compared with these previous studies.

There are certain limitations in our study. The sample size in the present study was small due to the strict inclusion and exclusion criteria. Only isolated simple mandibular fractures were included, which are rare because multiple facial fractures occur from road traffic accidents, which are the most common etiology of maxillofacial trauma in India. Due to lack of awareness in patients, post operative follow up period were to be minimised. Also, some patients did not consent to the study for various reasons. The microplates as well as the screws are comparatively expensive than the conventional miniplates which are cost effective.

For a better consistency of the presented evidences, it is suggested that larger cohort and multicenter clinical trials should be performed to evaluate the bite forces or even using electromyographic analysis to avoid possible biases.In addition, greater standardization of the size of

plates and screws used would increase the homogeneity of the results. The present study could open a scope for other interesting studies, such as a study of bite force in patients with facial deformity undergoing orthognathic surgery as well as patients treated with implant supported prostheses.

Conclusion

On the basis of our study we conclude that microplates are rigid enough to provide adequate stability to the fractured segments which is comparable to miniplates in the isolated fractures of mandible and can be preferred over miniplates. However, for comminuted fractures, more rigid plates should be used.

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