Bite Force Assessment of Mandibular Interforaminal Fractures Treated with Combination of Microplate and Miniplate—A Randomized Control Study

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Abstract

The purpose of this study was to compare the mechanical behavior of combination of microplate and miniplate with two standard miniplates for fixation of mandibular fractures in the interforaminal region on the basis of bite force and other clinical parameters. A prospective randomized study was conducted on 20 patients with mandibular fracture requiring open reduction and internal fixation (ORIF) who were randomly categorized into Group A and Group B with 10 patients in each group. Ten healthy persons whose age and gender matched with study groups were included in control Group C. Pre- and post-operative bite force was measured at specified intervals in both the study groups and was compared with the control group. The bite force values were comparatively less in Group A than Group B, although there was no statistically significant difference. Also, bite force values were less in both the study groups when compared with the control group. No statistically significant difference was found in other clinical parameters such as infection, fracture mobility, and hardware failure. The results were suggestive that the use of microplate and miniplate combination in management of minimally displaced mandibular fractures in the interforaminal region provides stable fixation comparable to two miniplate combination.

Keywords

- bite force
- mandible fracture
- microplate
- miniplate
- open reduction and internal fixation

Trauma to the facial skeleton frequently results in injuries to the soft tissues, teeth, and major skeletal component of the face, including mandible, maxilla, zygoma, naso-orbito-ethmoid complex, and supra orbital fractures.[1]

Proper anatomical reduction, restoration of the premorbid occlusion, and proper fixation until stable osseointegration are considered as the basic principles in treating mandibular fractures. Miniplates and reconstruction plates are commonly used to treat simple and comminuted fractures of mandible. However, thick fixation plates are bulky and palpable through the thin skin and the gingiva. A large miniplate placement in the interforaminal region in upper half of the mandible can result in complications such as infection, wound healing problems, tooth-root injuries, or mass-effect problems due to limited space available.[2]

In the mandible, because of thick compact bone, the difficulty in identifying the course of the dental roots leads to the probability of injury to the teeth which is three times higher than in the maxilla. It is desirable to minimize the size and amount of osteosynthesis material used, as there are

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reported cases of metal deposits in the neighborhood of titanium miniplates and also in the peripheral organs after osteosynthesis. Earlier microplates were used in nonstress-bearing areas such as midface, but recent experimental and clinical studies have shown that microplates can be used sufficiently in the stress-bearing areas of mandible.[3–5]

There are many experimental studies in the literature which have proposed various biomechanical and technical advantages of the microplate system over the miniplate system and very few studies have been done by comparing the bite force in patients treated with the microplate and miniplate system.[4]

The purpose of this study was to compare the mechanical behavior of combination of microplate and miniplate with two standard miniplates for fixation of mandibular fractures in the interforaminal region on the basis of bite force and other clinical parameters.

Materials and Methods

A prospective randomized clinical study was conducted from January 2014 to September 2015 on 20 patients with mandibular fracture in the interforaminal region requiring open reduction and internal fixations were selected for the study. The institutional ethics committee approval was taken prior to the study. They were randomly categorized into Group A, who were treated with one microplate (1.2 mm screw diameter, plate thickness 0.5 mm) and one miniplate (2.0 mm screw diameter, plate thickness 0.9 mm) and Group B, who were treated with two miniplates (2.0 mm screw diameter, plate thickness 0.9 mm). Ten patients in each group were included using chit withdrawal system in which both the patient and the operator were unaware of the specifics. Ten healthy persons were included in control Group C, whose age and gender matched with the study groups.

Patients with comminuted fracture of the mandible, concomitant midface and dentoalveolar fracture, infected fractures, and systemic diseases were excluded from the study. Preoperatively, a detailed medical and maxillofacial examination was done. The diagnosis was made based on clinical and radiographic (panoramic radiograph) interpretation and informed consent was taken prior to study. For patients who satisfied the inclusion criteria, preoperative bite force measurements were recorded at the central incisor, right first molar, and left first molar region three times at 2-minute intervals between each reading by using a digital bite force device (►**Fig. 1**) consisting of a force transducer to measure the maximum biting force (in Newton). One time bite force measurements were recorded for Group C patients whose age and gender matched with the study groups at central incisor, right first molar, and left first molar in a similar way.

The bite force device was designed at a reputable manufacturing center (HARIOM Electronics, Vadodara, Gujarat, India) and it was calibrated using a tensile testing machine at MSRIT (Bengaluru, India). Perioperative antibiotics and analgesics were administered as per our trauma protocol.

The selected patients were treated either under local or general anesthesia and the surgical technique was same for both the groups. All patients were treated by the same operating surgeon. Temporary maxillomandibular fixation (MMF) was done for isolated mandibular fracture by placing eyelets in both the arches followed by open reduction and internal fixation of fracture fragments. MMF for ~2 weeks was placed in case of associated condylar fractures.

A 0.5 mm × 4 holed titanium microplate was placed subapically and 0.9 mm × 4 holed conventional titanium miniplate at the inferior border of mandible and secured with monocortical 1.2 mm × 6 mm and 2 mm × 8 mm titanium screws, respectively, for Group A patients (►**Fig. 2**). Two 0.9 mm × 4 holed conventional titanium miniplates were placed subapically and at the inferior border of mandible and secured with monocortical 2 mm × 6 mm and 2 mm × 8 mm titanium screws for Group B patients (►**Fig. 3**) according to Champy's ideal line of osteosynthesis.

All patients were maintained under antibiotic coverage for 5 days postoperatively and were advised to be on liquid and semisolid diet for 2 to 3 weeks. The study subjects were advised to rinse frequently with chlorhexidine mouth wash and recalled for suture removal after 7 days. The study subjects were recalled and assessed on postoperative day 1, 7th day, 1st month, and 3rd month for the parameters such as bite force, occlusion, fracture stability, complications, and additional fixation if required.

During each follow-up, maximum bite forces at the central incisor, right first molar, and left first molar region was recorded. All measurements were made with the subject seated with the head upright, looking forward, and in an unsupported natural head position. The bite force

Fig. 1 Showing digital bite force recorder and bite force measurements at the central incisor, right first molar, and left first molar region by using bite force recorder.

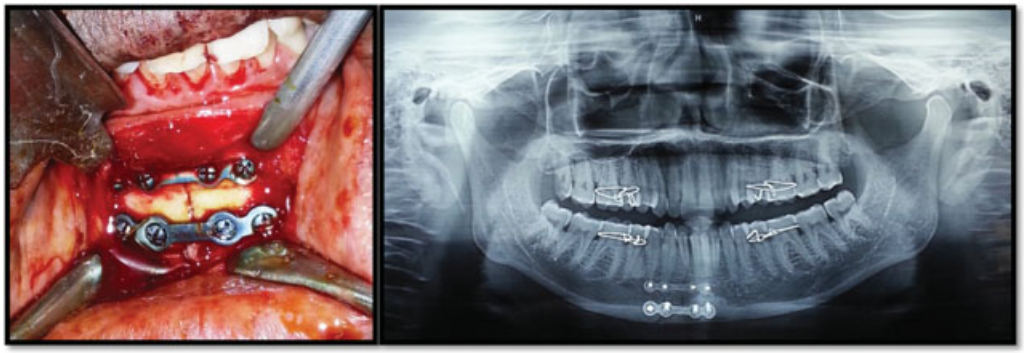

Fig. 2 Intraoperative photograph (left) and radiograph (right) showing fixation of right parasymphysis fracture with a microplate at the subapical region and a miniplate at the inferior border.

instrument could be conveniently positioned between a single pair of antagonizing cusps in the region of central incisor, right first molar, and left first molar region. The patients were advised to bite as forcefully as possible three times at 2-minute interval between each reading and the highest value was recorded in the data sheet.

Statistical Analysis

The data of all the patients were collected and tabulated using Microsoft excel sheet. Statistical analysis was performed using the SPSS software (IBM Corp., version 10.5) and the difference among the groups in terms of other parameters was determined by using the analysis of variance (ANOVA) test. Results were considered statistically significant if p-value is < 0.05.

Results

This randomized control study was done on 26 patients with mandibular fracture in the interforaminal region. Of these, four patients were excluded from the study because of associated midface injuries and two patients did not come for regular follow-up. Therefore, 20 patients were included in this study and were randomly categorized into Group A and Group B with 10 patients in each group and Group C with 10 healthy persons as control. Bite force was measured in Group A and Group B at different regions at different time intervals and were compared with the bite force of Group C.

In our study, of the 20 patients, 13 patients (65%) had isolated mandibular fracture in the interforaminal region. In Group A, four patients (40%) had right parasymphysis, two patients (20%) had left parasymphysis, and one patient (10%) had mid-symphysis fracture. In Group B, four patients (40%) had right parasymphysis, one patient (10%) had left parasymphysis, and one patient (10%) had mid-symphysis fracture.

In Group A, one patient (10%) had left parasymphysis with left undisplaced sagittal split condylar fracture, one patient (10%) had mid-symphysis with bilateral subcondylar fracture, and one patient (10%) had right parasymphysis with undisplaced right subcondylar fracture.

In Group B, one patient (10%) had left parasymphysis with right undisplaced subcondylar fracture, one patient (10%) had left parasymphysis with bilateral subcondylar fracture, and two patients (20%) had right parasymphysis with undisplaced left subcondylar fracture. The distribution of patients with condylar fracture was almost similar in both the study groups (three patients in Group A and four patients in Group B).

Mean bite force values recorded at different regions in the study groups were compared pre- and postoperatively (►**Figs. 4–6**). The mean bite force values recorded on postoperative day 1, 7th day, 1st month, and 3rd month did not show

Fig. 3 Intraoperative photograph (left) and radiograph (right) showing fixation of right parasymphysis fracture with two miniplates, one at the subapical region and one at the inferior border.

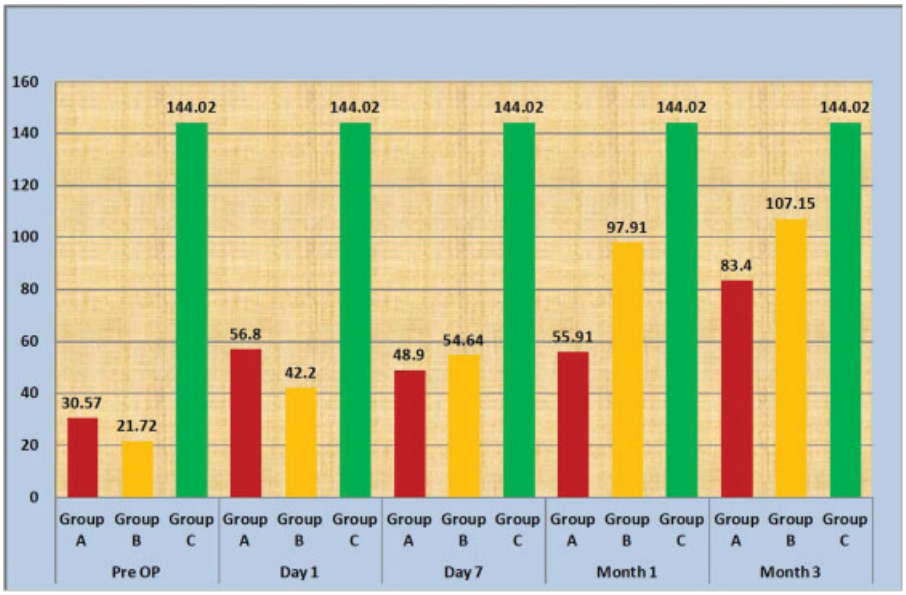

Fig. 4 Comparison of mean bite force at central incisor region between different groups at different intervals of time.

any statistical significance at central incisor (p-value = 0.529, 0.842, 0.165, 0.594), right first molar (p-value = 0.481, 0.720, 0.254, 0.953), and at the left first molar region (p-value = 0.579, 0.842, 0.254, 0.371), respectively (►**Table 1**).

The mean bite force values of Group A, when compared with that of Group C, showed lesser bite force readings at different time intervals. The mean bite force values on postoperative day 1, 7th day, 1st month, and 3rd month at right first molar (p-value = 0.000) and left first molar (p-value = 0.000) showed statistically significant results. However, the mean bite force value at central incisor was statistically significant on postoperative day 1, 7th day, and 1st month (p-value = 0.000), whereas statistically insignificant on 3rd month (p-value = 0.036) (►**Table 1**).

The mean bite force values of Group B, when compared with that of Group C, showed lesser bite force readings at different time intervals. The mean bite force values on postoperative 1st and 7th day showed statistically significant results measured at all the three sites (p-value = 0.000). However, the mean bite force values on postoperative 1st and 3rd month were statistically insignificant at all the three sites (►**Table 1**).

The assessment for fracture stability in both the study group showed favorable results from immediate postoperative to 3rd month follow-up. In both the study groups, 18 (90%) patients had satisfactory occlusion, while 1 patient (10%) from each study group had mild derangement of occlusion. Two patients in Group B developed infection at postoperative 7th day and 1 month, respectively.

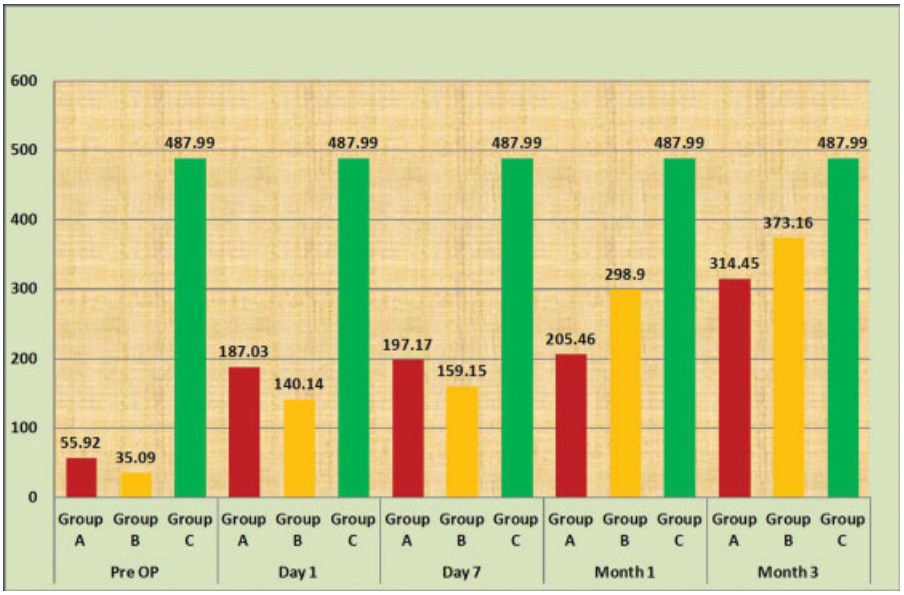

Fig. 5 Comparison of mean bite force at right first molar region between different groups at different intervals of time.

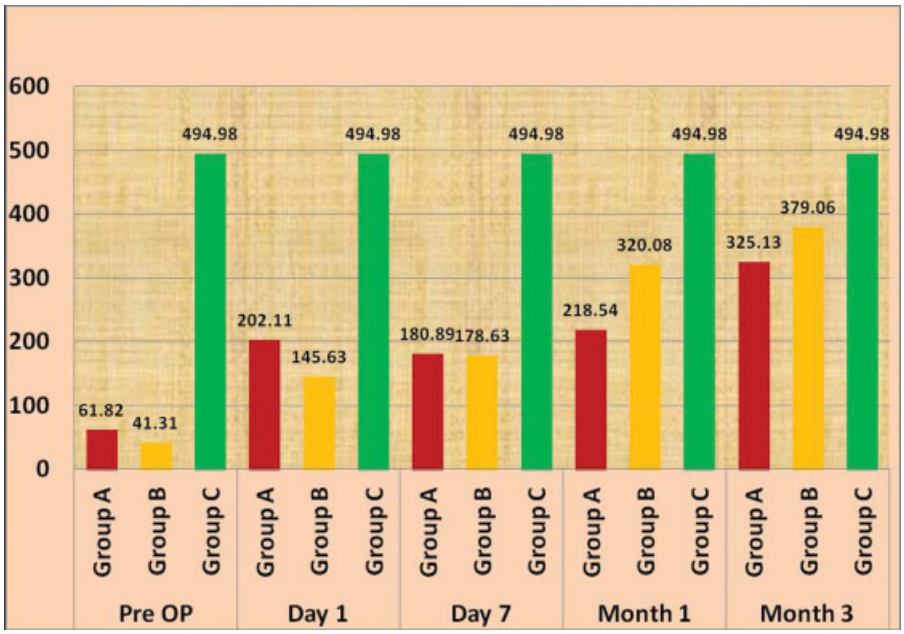

Fig. 6 Comparison of mean bite force at left first molar region between different groups at different intervals of time.

Discussion

The management of maxillofacial trauma, in general, and mandibular fractures, in particular, requires evaluation of the risks and benefits of each treatment modality and its application appropriately for each patient. As there are different treatment modalities available for managing mandibular fractures, it is imperative that we should consider the anatomic, physiologic, and biomechanical principles associated with managing these injuries.[1]

Table 1 Showing pairwise comparison between the groups at central incisor region, right first molar, and left first molar region by Mann–Whitney test (*p*-value)

	Group A vs. Group B	Group A vs. Group C	Group B vs. Group C
Central incisor region			
Preop	0.579	0.000	0.000
Day 1	0.529	0.000	0.000
Day 7	0.842	0.000	0.001
Month 1	0.165	0.000	0.168
Month 3	0.594	0.036	0.672
Right first molar region			
Preop	0.218	0.000	0.000
Day 1	0.481	0.000	0.000
Day 7	0.720	0.000	0.001
Month 1	0.254	0.000	0.053
Month 3	0.953	0.001	0.142
Left first molar region			
Preop	0.436	0.000	0.000
Day 1	0.579	0.000	0.000
Day 7	0.842	0.000	0.000
Month 1	0.254	0.000	0.033
Month 3	0.371	0.000	0.230

Miniplates and reconstruction plates are commonly used to treat simple and comminuted fractures of the mandible. However, thick fixation plates are bulky and palpable through the thin skin and gingiva. As there is limited space available in the upper half of the mandible for a large miniplate, it can result in complications such as infection, wound healing problems, tooth-root injuries, or mass-effect problems.[2]

In the mandible, because of thick compact bone, the difficulty in identifying the course of the dental roots leads to the probability of injury to the teeth which is three times higher than in the maxilla. It is desirable to minimize the size and amount of osteosynthesis material used, as there are reported cases of metal deposits in the neighborhood of titanium miniplates and also in the peripheral organs after osteosynthesis. Therefore, the size and amount of the osteosynthesis material used should be minimized. Previously, microplates were used in nonstress-bearing areas such as midface, but recent experimental and clinical studies have shown that microplates can be used sufficiently in the stress bearing areas of mandible.[3–5]

Therefore, we undertook a study to compare the combination of microplate and miniplate and two conventional miniplates in the management of mandibular fractures in the interforaminal region.

In our study, the distribution of patients according to the etiology was road traffic accident 14 (70%), self-fall 4 (20%), and assault 2 (10%). All 20 patients (100%) had unstable fracture at the time of admission. The gender-wise distribution of the patients in our study groups were Group A: 7 males, 3 females and Group B: 8 males, 2 females. The majority of the patients were male and the age distribution of the patients was

between 20 and 29 years with a mean age of 33.40 years in Group A and 24.60 years in Group B. In a retrospective study of 1,521 patients over a period of 20 years, it was found that the majority of the fractures occurred between the ages of 20 to 29 years and commonly in young men and the main etiological factor in their study were road traffic accidents.[6] In another study by Baig and Prasad,[7] on 20 patients with mandible fracture, the cause of injury was road traffic accidents and 18 patients were male and 2 patients were female and the age ranged between 20 and 40 years. In this study, in relation to incidence and age, distribution of the fractures had similar correlation with the study done earlier.

In our study, in Group A, seven patients (70%) had isolated mandibular fractures in the interforaminal region and three patients (30%) had associated condylar fracture, and in Group B, six patients (60%) had isolated mandibular fractures in the interforaminal region and four patients (40%) had associated condylar fracture, respectively.

In a retrospective epidemiological study in 237 patients treated for maxillofacial fractures, it was found that 30% of the mandibular fractures were in the symphyseal and parasymphyseal region.[8] In another study of 227 patients with mandibular fractures, 180 (79%) patients had single and 47 (21%) patients had double fractures.[9] In a study on 71 patients with mandibular fractures, 52 patients were treated in a prospective fashion. Thirty-four (65%) patients had unilateral and 18 (35%) patients had bilateral fracture.[10] In another study by Baig and Prasad, on 20 patients with mandible fracture, 14 patients had associated fractures.[7] In this study with respect to fracture site distribution, our results showed similar correlation with that of the studies which were done earlier.

Bite force is considered as one of the indicators of the functional state of the masticatory system that results from the action of jaw elevator muscles modified by the craniomandibular biomechanics.[11] Maximum occlusal force is one of the parameters of masticatory function which is relatively easy to measure and it has been used to study patients with dentofacial deformities both before and after surgical correction. The maximum occlusal force is reduced with fractures within the masticatory system.[12–18] Hence, this criterion was used in our study to compare the two types of plating system in the management of mandibular fracture in the interforaminal region by evaluating the maximum bite force and also to determine the rate of recovery of the bite force. Maximum bite force values at the central incisor, right first molar, and left first molar region both pre- and postoperatively was studied.

Preoperatively, there was a reduced bite force value in both the study groups compared with normal maximum voluntary bite force of healthy individuals. This could be attributed to neuromuscular splinting mechanism.

Mean bite force values recorded at different regions in the study groups were compared pre- and postoperatively (Figs. 4–6). The mean bite force values recorded on postoperative day 1, 7th day, 1st month, and 3rd month did not show any statistical significance at central incisor (p-value = 0.529, 0.842, 0.165, 0.594), right first molar (p-value = 0.481, 0.720, 0.254, 0.953), and at the left first molar (p-value = 0.579, 0.842, 0.254, 0.371), respectively, but with time there was a progressive increase in the bite force in both the study groups indicating returning of near normal bite force at different regions from postoperative day 1 to 3rd month follow-up.

The mean bite force values of Group A, when compared with that of Group C showed lesser bite force readings at different time intervals. The mean bite force values on postoperative day 1, 7th day, 1st month, and 3rd month at right first molar (p-value = 0.000) and left first molar (p-value = 0.000) showed statistically significant results. However, the mean bite force value at central incisor was statistically significant on postoperative day 1, 7th day, and 1st month (p-value = 0.000), whereas statistical insignificance (p-value = 0.036) indicated return to near normal bite force in the central incisor region at 3rd month postoperative follow-up.

The mean bite force values of Group B, when compared with that of Group C, showed lesser bite force readings at different time intervals. The mean bite force values on postoperative day 1 and day 7 showed statistically significant results measured at all the three sites (p-value = 0.000); however, on postoperative 1st month and 3rd month the results were statistically insignificant indicating near normal bite forces at 1st and 3rd month in Group B at all sites.

Group B patients showed higher bite force at 1st and 3rd month follow-up which was comparable with the control group. This implies that the patients treated with two miniplate combinations have achieved near-normal bite force at postoperative 1st month (except in left molar region) and 3rd month. This could be attributed to neuromuscular adaptation that takes place during healing.[17]

A preliminary study was conducted to measure the mean maximum bite force (MMBF) in healthy Indian individuals in the age group of 18 to 47 years with piezoelectric transducer device. The MMBF in Indian individuals was found to be 372.39 $\pm$ 175.93 N in the first molar region and slightly higher in males (448.47 $\pm$ 191.82 N) as compared with females (296.31 $\pm$ 116.79).[19] In another study, the measurement of voluntary bite force in 18 to 60 years individuals found that the bite forces ranged from 22 to 50 kg in the molar region and 3 to 27 kg in the incisor region and the mean adult healthy value (male and female) in the molar region were 36 kg and 15 kg in the incisor region.[20]

In this study, the bite force measurement was recorded between the study groups at different regions at different time intervals. It showed increase in the bite force values, from postoperative day 1 to 3rd month in both the groups which was significant. However, bite force comparison between the study groups showed no significant statistical difference and this was similar to the studies which were done earlier.

When there is a condylar process fractured on one side, the occlusal and masticatory forces get disturbed resulting in distribution of more loads to the contralateral side. This reduces the occlusal forces at the ipsilateral affected joint, and due to this the masseter activity on the fractured side decreases and increases on the nonfractured site. In a study on 155 patients (127 male, 28 female) with unilateral fractures of

the mandibular condylar process (91 treated closed and 64 treated open), maximum voluntary bite forces were recorded at 6 weeks, 6 months, and 1, 2, and 3 years after fracture. They concluded that maximum voluntary bite forces in patients treated for mandibular condylar process fractures do not differ significantly when treatment is open or closed and neuromuscular adaptations to the fractured mandibular condylar process occur in both groups.[17]

In this study, the bite force measurements in patients who had associated condylar fracture showed lesser bite force values on the side of condylar fracture at all time intervals. All the patients who had condylar fractures were treated with closed method (intermaxillary fixation for 2 weeks by using arch bar). The bite force values of patients with double fracture of the mandible in our study group were found similar to that of the study done earlier.

Fracture stability was assessed by simple digital palpation on either side of the fracture line and checked for the mobility of the fracture. Preoperative assessment of fracture fragments in both the study groups showed unstable fracture, whereas postoperative assessment from day 1 to 3 months showed stability at fractured site.

In this study, 18 patients (90%) in the study groups showed satisfactory occlusion from day 1 to 3rd month follow-up. However, mild occlusal derangement was observed in one patient (10%) from each group during follow-up which was statistically not significant. This could be attributed to associated condylar fracture which was managed with MMF. This was similar to that of a study done earlier on 34 patients with double mandibular fractures who were treated to evaluate the anatomical reduction and microplate fixation without MMF. They found no major complications including infection, plate exposure, nonunion, or significant malocclusion, and only five patients experienced a persistent but mild malocclusion with no need for additional management.[21]

A retrospective study, on 44 patients with fracture of maxillofacial skeleton treated with 1.0 and 1.5 mm microsystem, concluded that the overall complication rate for microsystem was 2.0%. The microsystem proved to be a reliable modality to fix fractures of the maxillofacial skeleton and the complications can be considered incidental and of neglectable clinical significance.[22] In this study, two patients in Group B developed infection, one in the 1st week and the other during the 1st month follow-up, respectively. The infection in the patients was managed with local conservative therapy such as wound debridement with antibiotic irrigation followed by oral antibiotics, analgesics, and chlorhexidine mouth rinse from the day of presentation to approximately for 7 days.

Overall, our study concludes that the rate of recovery of maximum voluntary bite force is same in both the groups at the end of 3 months postoperative period. The use of microplates at the upper border and miniplate at the lower border for stabilization of mandibular fractures in the interforaminal region provided satisfactory results. In summary, microplate and miniplate combination for treatment of minimally displaced fractures in the interforaminal region provides stable fixation, satisfactory occlusion, and bite force with no incidence of infection.

In conclusion, with our results, it can be suggested that the use of microplate and miniplate combination in the management of minimally displaced mandibular fractures in the interforaminal region helps in achieving stable fixation, satisfactory occlusion, and early return to function at the same time minimizing the foreign body material. However, with the use of microplate and miniplate combination, the bite force values were slightly less than the miniplate group and the healthy controls indicating a lag in the neuromuscular adaptation. Further prospective randomized control studies with a large sample size and longer follow-up are essential to evaluate this system for suitability in regular use.

Funding
None.

Conflict of Interest
None.

Patient Consent
All patients provided written informed consent for the study and permission was obtained to publish the photographs.

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