Assessment of Masticatory Function Using Bite Force Measurements in Patients Treated for Mandibular Fractures

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Abstract

Bite force measurements are excellent criteria for assessment of masticatory efficiency. The purpose of this study was to assess the effect of mandibular fractures on the bite forces of patients treated for such fractures. Patients who were surgically treated for isolated mandibular fractures in the Department of Oral and Maxillofacial Surgery from January 2006 to December 2007 were included in the study. Patients were asked to bite on a bite force transducer on the first, fourth, sixth, and ninth postoperative weeks. The bite force values were compared with those of age, sex, and weight-matched controls. A total of 60 patients were included in the study. It was found that maximum bite forces in patients were significantly less than in controls for several weeks after surgery. After the ninth postoperative week, the maximum bite force measured $< 65\%$ the normal in patients with isolated angle fractures and $> 80\%$ the normal in patients with isolated parasymphysis fractures. The same values reduced to $< 60\%$ in patients with fractures of angle and parasymphysis and $< 70\%$ in patients with fractures of parasymphysis and condylar complex. An inverse relationship was found between the bite force values and the number of fractures of the mandible. We also found lower bite forces and longer period for normalization in patients who had fractures in those regions of the mandible which are more significantly associated with the masticatory apparatus for example angle or condyle of the mandible.

Keywords
- bite force
- masticatory apparatus
- mandibular fractures

Masticatory function refers to the ability of a person to masticate or chew without pain or interference. The major determinants of masticatory function are the range of mandibular motion, occlusion, maximum occlusal forces, and the activity of masticatory muscles.[1] This function is affected in dentofacial abnormalities and in traumatic and pathological injuries to the jaws.

Fractures of the mandible not only cause a change in the skeletal architecture but also lead to changes in the other components of the masticatory apparatus in the form of masticatory muscle tear or injury and neurovascular injuries. Surgical treatment of mandibular fractures aims at restoration of skeletal form of the mandible with a hope that normal function and esthetics would be restored. In the process of any such surgical treatment, the resultant soft tissue injury in the form of stripping of masticatory muscles and iatrogenic neurovascular injury can further affect the masticatory apparatus. Although occlusal position can be restored surgically, it is unknown whether the patient might be able to produce occlusal loads, secondary to the changes in hard and soft tissue components of the masticatory apparatus either due to the fracture and/or its surgical

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treatment.[2] Maximum occlusal forces are an important and a significant parameter of masticatory function and also are relatively easy to measure and analyze.[3] These forces depend upon the occlusion, number of muscle fibers recruited for function, and the force created by these recruited masticatory muscle fibers. Thus, when used in patients treated surgically for mandibular fractures, records of maximum occlusal forces act as excellent assessment criteria for restoration of skeletal architecture and repair and healing of masticatory soft tissues.

The purpose of this study was to assess the effect of mandibular fractures on the bite forces of patients treated for such fractures. An attempt was also made to compare the effects of various mandibular fractures on the maximum occlusal forces.

Materials and Methods

- Study sample: All patients who underwent open reduction and internal fixation for isolated mandibular fractures in the Department of Oral and Maxillofacial Surgery from January 2006 to December 2007 were included in the study. The exclusion criteria were: (1) patients with associated mid-face fractures, (2) edentulous patients, (3) patients below 14 years of age, and (4) medically compromised patients.
- Data collection method: Bite forces were measured between occluding molar teeth using a pressure sensor (customized bite force machine). Each patient was asked to sit erect with a relaxed head posture, keeping the Frankfurt horizontal plane parallel to the floor. Patients were asked to bite on the pressurized tube 3 times in succession, resting 5 seconds between each bite. The largest value was chosen as the maximum bite force. The bite forces were recorded at four occasions—first, fourth, sixth, and ninth postoperative weeks.
- The bite force equipment: The transducer designed for the study was similar to the one described by Braun et al.[4] The transducer consists of a disposable pressure reinforced tube connected to a pressure sensing element. The pressure change is transformed into an electrical signal and transferred to a digital strain indicator.
- Data analyses: For analyzing the data patients were divided into five groups. Group I included patients with isolated angle fractures. Group II included patients with fractures of unilateral angle and ipsilateral or contralateral parasymphysis. Group III consisted of patients with fractures of isolated parasymphysis. Group IV included patients with fractures of unilateral parasymphysis and ipsilateral or contralateral condylar complex. Group V included patients with fractures in more than two sites in the mandible. Bite force measurements of the patients were compared with those of age, sex, and weight-matched controls. The bite force measurement of the control was considered as the desired maximum bite force measurement for the corresponding patient. The observations were statistically analyzed using the student's unpaired *t*-test.

Results

A total of 60 patients with isolated mandibular fractures, treated by open reduction and internal fixation, were included in the study. Of the 60 patients, there were 29 patients with fracture of unilateral parasymphysis with fracture of ipsilateral or contralateral condylar complex (head, neck, or subcondyle), 12 with fracture of unilateral angle and ipsilateral or contralateral parasymphysis, 7 with fracture angle, 6 with fracture parasymphysis, and 6 with fractures in more than two sites in the mandible. The average age of the patients was 27 years ranging from 17 to 44 years. The average weight of the patients was 60 kg ranging from 40 to 80 kg. The maximum bite forces were directly proportional to the age and weight of the patients in this study sample as found in studies done earlier.[5] Also males had a higher maximum biting force than females.[6]

All the patients showed a significant increase (►**Table 1**) in the bite force values from the first to the fourth postoperative week ($p = 0.0000$). The bite force values also increased significantly from the fourth to the sixth postoperative weeks ($p = 0.0000$). The bite force increase from the sixth to the ninth week was also significant though the percentage of increase was less (►**Table 2**).

- Results of groups I and III: Patients with fractures of unilateral angle showed a maximum of 65% recovery of normal bite forces and with fractures of unilateral parasymphysis showed not less than 80% recovery of normal bite forces by the ninth postoperative week.
- Results of group II: Patients with fracture of the angle and parasymphysis showed a maximum of 60% recovery of normal bite forces by the ninth postoperative week; the bite force on the fracture angle side being lower than parasymphysis side.
- Results of group IV: Patients with fracture of parasymphysis and condyle showed not less than 70% recovery of normal bite forces by the ninth postoperative week; the bite force on the side of the condylar fracture being lower than that of the parasymphysis side.
- Results of group V: Patients with fractures in more than two sites in the mandible showed a varied presentation.

Table 1 Comparison of control and ninth postoperative week groups

Group	Mean	SD	*t*-value	*p* value	Significance
Ninth POW	46.9364	9.1714	–9.4954	0.0000	S
Control	69.6744	7.6968	–	–	–

Abbreviations: POW, postoperative week; SD, standard deviation.

Table 2 Comparison of bite force on various postoperative weeks by student unpaired *t*-test

POW	Mean	SD	Mean diff	Percentage of change	SD diff	Paired *t*-test	*p*-value
First POW	8.4844	4.4534	–	–	–	–	–
Fourth POW	29.6892	6.2457	–21.2048	–249.9269	6.6157	–16.0262	0.0000
First POW	8.4844	4.4534	–	–	–	–	–
Sixth POW	39.9796	6.9986	–31.4952	–371.2130	6.9416	–22.6858	0.0000
First POW	8.4844	4.4534	–	–	–	–	–
Ninth POW	46.9364	9.1714	–38.4520	–453.2082	8.5476	–22.4928	0.0000
Fourth POW	29.6892	6.2457	–	–	–	–	–
Sixth POW	39.9796	6.9986	–10.2904	–34.6604	6.4292	–8.0029	0.0000
Fourth POW	29.6892	6.2457	–	–	–	–	–
Ninth POW	46.9364	9.1714	–17.2472	–58.0925	8.0732	–10.6817	0.0000
Sixth POW	39.9796	6.9986	–	–	–	–	–
Ninth POW	46.9364	9.1714	–6.9568	–17.4009	3.2882	–10.5785	0.0000

Abbreviations: diff, difference; POW, postoperative week; SD, standard deviation.

Restoration of normal bite forces ranged from 45 to 65% by the ninth postoperative week.

Discussion

Fractures of the mandible, though not a grievous injury, are a great cause of concern for the patient. This is because such fractures have a significant effect on mastication, a function unique to the craniofacial musculoskeletal system. This study was conducted to assess the magnitude of damage of the masticatory system caused by mandibular fractures and the effect of various mandibular fractures on the maximum bite forces.

Trauma to the facial region frequently results in injury to soft tissues, teeth, and major skeletal components of the face, including the mandible, maxilla, zygoma, naso-orbital-ethmoid complex, or supra orbital structures. Participation in the management and rehabilitation of the patients with facial trauma involves a thorough understanding of the types of principles of evaluation for and surgical treatment of facial injuries. Whenever facial structures are injured, the goal of the treatment must be maximal rehabilitation of the patient.[7] For facial fractures, goals of treatment include rapid bone healing, a return of normal ocular, masticatory and nasal function, reconstruction of speech and an acceptable facial and dental esthetic result.

Fractures of the mandible alone account for a large proportion (~70%) of all facial injuries.[7] Because of the importance of the mandible as vital component of the masticatory apparatus, such injuries can be expected to significantly alter occlusion, mandibular range of motion, muscle activity levels, and occlusal forces.[8] The last of these, that is, maximum occlusal forces, are excellent assessment criteria for restoration of the skeletal architecture and the repair and healing of masticatory soft tissues.[3]

The significant reduction of bite forces following treatment of fracture mandible might be explained by traumatic or operative trauma to the muscle of mastication or to protective neuromuscular mechanisms of the masticatory system.[9] Furthermore, the patient's willingness to bite hard is also a major factor. This is related both to mental attitude and to the comfort of the teeth, so some patients, especially within the first postoperative week, are afraid to use their jaws vigorously.[10] This could be the reason for the very low values of bite forces recorded in this study at the end of first postoperative week.

From the first postoperative week, the bite force values increase steadily both on the fractured side and on the nonfractured side. There was a significant increase ($p = 0.0000$) in the bite force values in all the three intervals of time after which bite force was measured (►**Table 1**). It was also noticed that the increase in the bite force values from the sixth to the ninth postoperative week was less compared with other intervals. One of the possible reasons for this phenomenon is the regeneration of the inferior alveolar nerve and reinnervation of the reflected periosteum with return of pain sensation.[11]

The result showed a difference in the restoration of maximum bite forces with respect to the location of fractures in the mandible. (A statistical analysis was not possible for this comparison due to the small sample size of each of the groups.) In the first group bite force restoration was at least 80% of the normal by the ninth postoperative week. Such a high value of bite force restoration can be attributed to the fact that isolated fracture at the parasymphysis of the mandible is associated with very few components of the masticatory apparatus. Masticatory muscle injury at the time of the fracture or surgery is almost zero. In the second group, where patients had a condylar complex fracture along with parasymphysis fracture, the results were not as high as in group I. The bite force restoration was a maximum of 70% the normal.

The possible reasons[3,12] for reduction in the bite force restoration could be (1) pain or discomfort on biting due to involvement of a component of the temporomandibular joint (TMJ) that is, condyle. (2) A possible increased mandibular plane angle secondary to an open bite resulting from condylar fracture. (3) Effects on the central nervous system to reduce loading of the fractured condylar process. In patients with isolated fractures of the angle, bite force restoration was a maximum of 65% of the normal. The most important reason for the bite force restoration after treatment of fractures of the mandibular angle is traumatic and surgical damage to the masseter and temporalis muscle. Placing fixation hardware from intraoral approach necessitates the masseter muscle and at times a portion of the insertion of the temporalis muscle being stripped from their attachments to the lateral border of the mandible. Another probable reason for reduced bite force restoration in group III is the presence of protective neuromuscular mechanism in the form of muscle splinting, where selective components of the neuromuscular system are activated or deactivated to take forces off the damaged system.[11] In patients with fractures of the angle associated with fracture of ipsilateral or contralateral parasymphysis, the bite force restoration was lower than that seen in group III. At the end of ninth postoperative week, bite forces were found to be not greater than 60% of the normal. The reason for this difference can be attributed to the added neural protective mechanisms present in the periodontal ligaments of the teeth. In patients with fractures of mandible in more than two sites, the bite force restoration varied from 45 to 65% of the normal, depending on the location of fracture and the role of this location in the masticatory apparatus. In one of the patients in this group, where there were fractures of bilateral condyle, angle, and parasymphysis, bite force restoration on the ninth postoperative week was as low as 40% probably due to involvement of almost all components of the masticatory system.

Based on these results we conclude that mandible fractures adversely affect maximum bite forces, although temporarily. Fractures of the condylar region have a stronger influence on the bite forces than fractures at other sites of the mandible. These fractures also take a longer time for normalization. This was followed by the fractures of the angle of mandible, which take comparatively less time for normalization with respect to maximum bite forces. Fractures in any other region of the mandible have a weaker influence on the bite forces and also reach normal values faster. To analyze our findings further we suggest a similar study with a larger sample size and supplemented with electromyographic studies for postsurgical recruitment to function of masseter and temporalis muscles.

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