OPEN ACCESS
Global Journal of Research in Dental Sciences
ISSN: 2583-2840 (Online)
Volume 02| Issue 02 | March - April | 2022
Journal homepage: https://gjrpublication.com/journals/

Perspective

Comparative evaluation of bite force between healthy individuals and treated cases of isolated mandibular fractures

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DOI: 10.5281/zenodo.6510091 **Submission Date:** 27th April 2022| **Published Date:** 30th April 2022

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Abstract

Aim and objectives: To compare the bite forces between healthy individuals and treated cases of isolated mandibular fractures.

Material and method: This prospective study consisted of 10 patients with isolated mandibular fractures, requiring open reduction and internal fixation (ORIF) with miniplates for study group. Control group consisted 10 healthy individuals with. Each group consisted individual with the age ranging from 18 to 60 years. The bite force was measured by the digital gnathodynamometer, immediately after IMF removal at 2nd, 4th, 8th week's interval and 3, 6, 9 months.

Result: Bite force generated by patients treated with ORIF with miniplates remains low as compared to normal healthy individual till 4th post-operative week. From 4th week to 9 months it steadily increases. It was also noticed that the increase in the bite force values from 3 to 9 months was less compared with other individuals.

Conclusion: It was observed in our study that mandibular fractures have a negative impact on maximum bite forces. Bite forces bring the body closer to normal over time, but it does not totally restore normaly.

Keywords: Bite force, digital gnathodynamometer, mandibular fracture, intermaxillary fixation.

Introduction

Management of trauma has always been one of the surgical subsets in which oral and maxillofacial surgeons have excelled over the years. Clinically the mandible is the second most common facial bone to be fractured because of its position and prominence. The treatment of mandibular fractures has been studied over the past many decades. Treatment philosophies continue to evolve with goals to restore function and premorbid occlusion. Restoration of mandibular function, in particular, as part of the stomatognathic system must include the ability to masticate properly, to speak normally, and to allow for articular movements as ample as before the trauma. In order to achieve these goals, restoration of the normal dental occlusion in each patient becomes paramount for the treating surgeon.[1]

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 due to masticatory muscle tear or injury and neurovascular injuries. Because of the importance of the temporomandibular joint (TMJ) as a vital component of the masticatory apparatus, mandibular fractures can significantly alter occlusion, mandibular range of movement, muscle activity levels, and occlusal forces.[7] Functional efficacy of masticatory muscle following treatment of mandibular fractures have received little attention.[2]

Bite force is one indicator of the functional state of the masticatory system which results from the action of jaw elevator muscles modified by the craniomandibular biomechanics. Bite force has been considered important in the diagnosis of the disturbances of the stomatognathic system.[8,9] Maximum bite force is one parameter of masticatory function that is relatively easy to measure.[6,10] In fracture cases, the maximum bite force in masticatory system is considerably reduced.[7,10,11] Records of maximum bite force measurement in surgically treated patients of mandibular fracture act as an excellent assessment criteria for restoration of skeletal architecture and repair and healing of masticatory soft tissues.[6]

The first experimental study defining the measurement of bite forces was performed in 1681 by Borelli, who designed a gnathodynamometer. Subsequently on this subject, several researchers continued to investigate and designed various devices like the lever-spring, manometer-spring and lever, and micro-metered devices. Gnathodynamometer has been used to measure bite force for a long time. Some investigators have used strain-gauges mounted dynamometer for recordings. Today, sensitive electronic devices are in use.[8]

MATERIAL AND METHODOLOGY

The study was conducted in the Department of Oral and Maxillofacial Surgery in College of Dental Science and Research Centre, Ahmedabad. In this study two groups were made control group and study group. Out of 20 patients, 10 patients were in control group and 10 patients, who reported with isolated fracture of the mandible, were included in study group. Ethical committee approval was obtained prior to the commencement of the study.

Bite force recordings were made using digital gnathodynamometer in kilogram (Kg). (Fig. 1) Each of the patients was seated in the dental chair in natural, upright and unsupported position. The bite pads were covered with fresh RVG sleeves for each patient to prevent cross infection. The subjects were instructed to bite on the pads of bite force gauge. Subsequently, each of the patient was asked to carry out a maximum voluntary comfortable bite force (MVCBF), lasting 2-3 seconds, at three different locations (anterior, right posterior and left posterior regions) within the dental arch, with each recording accompanied by 5 seconds interval. For each of three positions, the peak bite force was measured and accordingly recorded, with each participant's highest of three taken as MVCBF.(Fig. 2)

Post-operative bite force in kg were recorded in anterior, right and left posterior regions. Immediate after internal maxillary fixation removal, after 2,4,8 weeks and after 3,6,9 months.

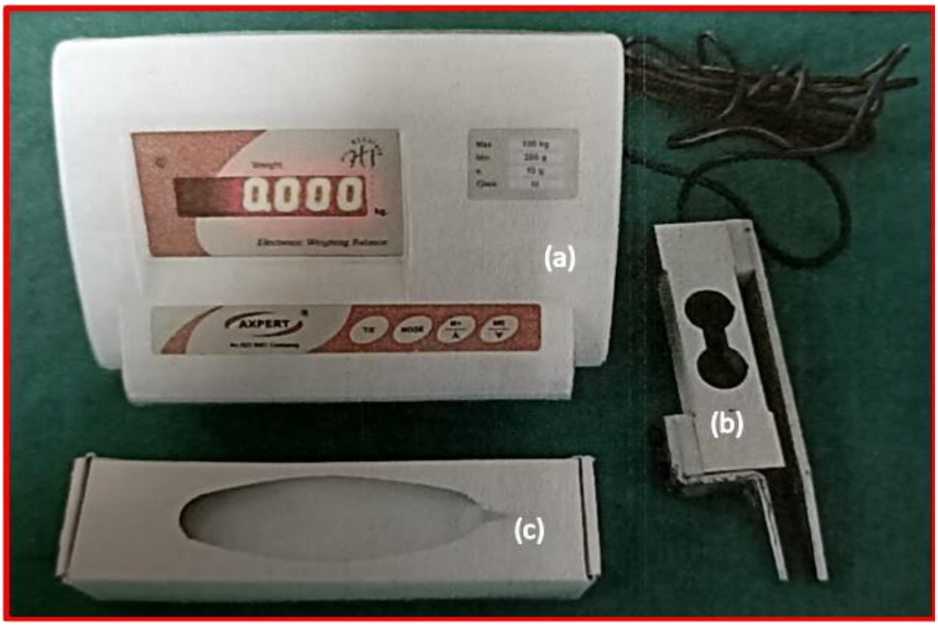

Fig._1: Digital gnathodynometer. (a) Electronic instrument, (b) Metallic fork, (c) Batteries for instrument amplifier and digital panel meter.

Control group:

The group consisted of 10 healthy volunteers (5 males and 5 females) who met the below mentioned inclusion and exclusion criteria.

Inclusion criteria:

1. Age group between 18-60 years.
2. Patients with no history of any previous orthodontic or orthognathic treatment.
3. Patients without any neurosensory deficits and sign and symptoms of temporomandibular joint/myofunctional pain and dysfunction.
4. Patients with adequate dentition with minimal restoration to perform bite force measurement.
5. No sensitivity to percussion on the teeth to be tested and patient willingness.

Exclusion criteria:

1. Medically compromised with extremes of age.
2. Patients with previous history of major reconstructive maxillofacial surgeries like grafting after partial resection and those with disabilities.
3. Patients with implant supported tooth replacement or removable prosthesis or any form of fixed prosthesis.
4. Patients with compromised dentition and carious or root canal treated incisors, premolars and molars.

Study group:

10 patients with isolated mandibular fracture were included in study group. Its inclusion and exclusion criterias are mentioned below. Bite forces were recorded by digital gnathodynometer in isolated mandibular fractures, which were operated for ORIF with miniplates. Out of 10 patients, only 4 were treated with extra oral approach. Placing fixation hardware in such patients (for angle and body fractures) necessitates the masseter muscle and a portion of the insertion of the temporalis muscle being stripped from their attachments to the lateral border of the mandible. In 6 patients (for symphysis and parasymphysis) miniplate hardware were fixed with intraoral approach. In all the patient internal maxillary fixation (IMF) was kept for 7 to 10 days.

Inclusion criteria:

1. Age group between 18-60 years.
2. Patients with non-comminuted, non-infected mandibular fracture with no other facial bone fracture.
3. Patients without any neurosensory deficits and signs and symptoms of TMJ/ myofunctional pain and dysfunction.
4. Patients with adequate dentition with minimal dental restoration to perform bite force measurement.
5. No sensitivity to percussion on the teeth and patient willingness.

Exclusion criteria:

1. Medically compromised patients with extremes of age contraindicating general anesthesia.
2. Patients with previous history of major reconstructive maxillofacial surgeries like grafting after partial resection and those with disabilities.
3. Patients with compromised immunity, concomitant midrace and dent alveolar fractures and associated bone pathology.
4. Edentulous patients.

Fig._2: Study group. (a) Post-operative OPG, Bite force measurement after – (b) IML removal, (c) 4 weeks of treatment, (d) 3 months of treatment, (e) 6 months of treatment, (f) 9 months of treatment.

Result

Control group			Study group			
Anterior Region	**Right posterior region**	**Left posterior region**	**Follow up period**	**Anterior region**	**Right posterior region**	**Left posterior region**
			After IMF removal	2.840	4.950	5.100
			After 4 weeks	6.800	12.210	12.650
			After 3 months	10.640	18.530	17.640
			After 6 months	12.130	23.520	22.920
17.453	29.817	29.759	**After 9 months**	14.180	24.550	23.780

Table-1: Bite forces in control group and study group

Control group:

In this study, in control group the bite forces were in the range of 13 to 20 kg in anterior region and 23 to 35 kg in posterior regions. The right and left posterior regions did not show any significant difference in bite force. The mean adult healthy individual in this study showed the mean bite force of 17.453 kg in anterior region and 29.817 kg in right posterior region and 29.759 kg in left posterior region. (Table 1)

Study group:

After IMF removal (2 weeks after ORIF), in anterior region, the bite force was only 16% of control group. These values rose to 39% after 4th week, 61% after 3 months, 70% after 6 months and 81% after the end of 9 months. In posterior right region, the bite force was 16% after 2nd week, 41% after 4th week, 62% after 3 months, 79% after 6 months and 82% at the end of 9 months. In posterior left region, the bite force was 17% after 2nd week, 42% after 4th week, 59% after 3 months, 77% after 6 months and 80% at the end of 9 months. (Table 1)

From the 4th postoperative week, the bite force values increased steadily. There was a significant percentage increase in the bite force values after 4 weeks, 8 weeks, after 3 months. It was also noticed that the increase in the bite force values from 3 to 9 months 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.[6,11] These findings were in accordance with the findings of the studies conducted by Gerlach et al., Tate et al., Kumar et al., Sybil et al., Kshirsagar et al., and Ellis and Throckmorton.[2,6,10,11,12,15] In anterior region, the bite force restoration of study group individuals was almost 81% of the control group after 9 months. Such a high value of bite force restoration can be attributed to the fact that isolated Para symphysis fracture of the mandible is associated with very few components of the masticatory apparatus. (Table 1)

Masticatory muscle injury at the time of the fracture or surgery is almost zero. As against this, the bite force restoration of study group individuals in posterior right region was 82% of the control group after 9 months and in posterior left region same was 80%. This is because of the operative trauma to the muscles of mastication. (Table 1)

Discussion

Trauma to the facial region frequently results in injury to soft tissues, teeth, and major skeletal components of the face, mainly the mandible, maxilla, zygoma, naso-orbital-ethmoid complex, or supra orbital structures. Fractures of the mandible are a great cause of concern for the patients. This is because such fractures have a significant effect on mastication, a function unique to the craniofacial musculoskeletal system.[5,6]

In the management of any facial bone fracture, the goals of treatment are to restore proper function and esthetics by ensuring union of the fractured segments, re-establish preinjury strength, and to prevent any contour defect that might arise as a result of the injury, and to prevent infection at the fracture site.

Guglielmo Salicetti in 1492 introduced the concept of IMF, which was later popularized by Gilmer in 1887. The concept of open reduction for fractures of the mandible was introduced by Buck using an iron loop, and subsequently followed by Gilmer and Luhr.[2,3] More recently the use of internal fixation utilizing plates has shown the highest success rates with the lowest incidence of non-union and postoperative infections.[1,5,17] Miniplate osteosynthesis, introduced in

1973 by Michelet and colleagues and further developed by Champy et al. in 1978, has become the modern line of treatment for mandibular fractures." Champy et al. described a novel and currently the most accepted concept of using non-compression mono cortical miniplates in the regions, referred to as "Champy's lines of osteosynthesis."[1,2,3,4,5,12]

Along the entire course of the mandible, muscle attachments exert dynamic internal forces on the mandible. These muscles can be divided into two basic groups: muscles of mastication and suprahyoid muscles. The muscles of mastication include the medial and lateral pterygoids, the temporalis, and masseter muscles. Together these muscles aid in chewing by generating forces along the posterior aspects of the mandible (angle, ramus, coronoid process).[5] This chewing force is known as bite force. Bite force can be defined as the forces applied by the masticatory muscles in dental occlusion.[2,16] Furthermore, two of the muscles of mastication, the medial pterygoid and masseter muscles, combine to form the pterygomasseteric sling, that attaches at the mandibular angle. Conversely, the suprahyoid group (digastric, stylohyoid, mylohyoid, and geniohyoid) functions, in part, to depress the anterior mandible by applying forces to the mandibular symphysis, parasymphysis, and a portion of the body. Together, these muscle attachments act to place dynamic vectors of force on the mandible that, when in continuity, allow for proper mandibular function, but when in discontinuity, as occurs with mandible fractures, can potentially disrupt bite force and appropriate fracture healing and bite force. Hence, bite force is the result of the coordination between different components of the masticatory system which includes muscles, bones, and teeth.[9,13,14,17] Various techniques and devices are utilized to evaluate bite force, including portable hydraulic pressure gauges, the bite fork, force sensing resistors, and strain gauge.[14,17]

Bite force varies in different regions of the oral cavity. The more posteriorly the bite fork is placed in the dental arch, the greater the bite force. Greater bite force can be tolerated better in posterior teeth, because of the larger area and periodontal ligament around posterior teeth roots. Also, different positions of the bite fork in dental arch may influence the different muscles that are involved in force production. If the bite fork is placed anteriorly between the incisor teeth, the masseter muscle will produce most of the force together with the medial pterygoid muscle. If the bite fork is more posteriorly placed, then anterior fibres of the temporalis muscle will become more active and hence make a greater contribution to the efforts.[8]

A person with a complete dentition and good occlusal relationship will probably demonstrate better masticatory performance than someone with fewer occlusal contacts. Like-wise, someone who generates higher force during mastication might have a better masticatory performance. For instance, someone with carious, painful teeth will subconsciously avoid those teeth during mastication just because of the fear of pain or breakage of teeth. This results in reduced performance of mastication. This in turn weakens the bite force by the same regulating reflex system due to the negative feedback reflex from the periodontal receptors. This was the reason that the subjects with carious teeth, periodically and periodontal involved teeth were excluded from the study.

The significant reduction of bite forces following treatment of fracture mandible might be explained by traumatic injury or operative trauma to the muscles of mastication. Furthermore, the patient's willingness to bite hard 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. This could be the reason for very low values of bite forces recorded immediately after IMF removal.

In the process of ORIF of mandibular fracture, the resultant soft tissue injury in the form of stripping of masticatory muscles and latrogenic neurovascular injury can further affect the masticatory apparatus. Hence, the significant reduction of bite forces following treatment of fracture mandible might be explained by traumatic or operative trauma to the muscles of mastication or to protective neuromuscular mechanisms of the masticatory system. For instance, one of the first protective mechanisms seen when a fracture of a long bone occurs is muscle splinting, where selective components of the neuromuscular system are activated or deactivated to take forces off the damaged skeleton. Similar muscle activation or deactivation can be seen in mandibular fracture, leading to reduction in the amount of generated force. Another probable reason for a decrease in bite force in the posterior region after treatment of fractures of the mandibular is traumatic and surgical damage to the masseter and temporalis muscles.

Conclusion

Bite force measurement is an underexplored area of maxillofacial surgery. Bite force measurement by digital gnathodynamometer is a simple, easy, quick, sensitive, curate, inexpensive, and chair-side procedure to clinically evaluate the effectiveness of masticatory muscles after mandibular fracture management. Based on the results of this study it was concluded that mandibular fractures adversely affect maximum bite forces. Bite forces approaches to normal over a period of time, but it does not completely reverts normal, as seen in this study.

To analyse these findings further, a similar study with a larger sample size can be supplemented with Electromyographic studies in postsurgical phase to evaluate the function of masseter and temporalis muscles. The present study could open doors 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 prosthesis.

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CITE AS

S.Madan, D.Mehta, Setu .P. Shah, Nishith Shah, & Smit kapatel. (2022). Comparative evaluation of bite force between healthy individuals and treated cases of isolated mandibular fractures. Global Journal of Research in Dental Sciences, 2(2), 24–29. https://doi.org/10.5281/zenodo.6510091