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Evaluation of masticatory efficiency using Bite Force Measurement in treated mandibular fractures with miniplates.

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INTRODUCTION

Maxillofacial injuries are routinely encountered in our practice and can lead to severe disfigurement and alter one's facial form. Facial injuries can also result as a serious blow to one's self esteem and psychosocial functioning, as there is a great emphasis on one's appearance in the society.As a result, maxillofacial injuries require prompt and expert therapy to return to their normal shape and function. Road traffic accidents (RTA) are the most frequent cause of maxillofacial injuries in developing nations like India, followed by interpersonal disputes, unintentional falls, sports injuries, and industrial accidents.[1]

The bone in the maxillofacial skeleton that fractures most commonly is the mandible, owing to its prominence and dynamic nature in the face. In addition there are a number of anatomical as well as biomechanical factors making it more vulnerable to fracture. Some sections of the jaw are naturally weaker than others due to the osteo-anatomy of the mandible, numerous muscle attachments and their effects, as well as the presence of developing or full dentition. The condylar neck, the mandibular angle, the mental foramen, and the area lateral to the mental protuberance are among these weak spots. Teeth cause the socket to become a weak zone, especially if they are impacted or do not erupt.[2] Based on anatomic location, the most common site of fracture in the mandible is body (33.0%), condyles (29.3%), angle of the mandible (23.1%), symphysis (8.4%), ramus (2.6%) and coronoid (2.2%) in the decreasing order.[3,4]

Fracture of the mandible causes damage to the masticatory apparatus as well. The efficiency of chewing food, speaking and swallowing is deteriorated following mandibular fractures. This is attributed to direct damage to mandible, associated dentoalveolar components and temporomandibular joint, injury to surrounding muscles and alterations in the neuromuscular co-ordination. Management of mandibular fracture should aim at restoring the pre-trauma anatomic form, associated esthetics and function. In specific the occlusal contacts should be re-established to

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improve the bite force and thereby the masticatory efficiency.

The main objective of fracture treatment is to return the body to its natural form and function. As the maxillomandibular apparatus is concerned, the normal occlusion and efficiency of chewing would indicate return to normal form and function. However most of the studies in the literature have assessed the return of masticatory function subjectively while the bite force is a quantitative factor which indicates the efficiency of the masticatory system.[3]

The maximum bite force a person can produce is a clinical and direct measure of the masticatory system's functioning status. The mechanics of mastication and the therapeutic impact of prosthetic devices have both been studied using this component in the realm of dentistry. The link between masticatory function and maximum bite power has been demonstrated in numerous research.[5]

It is challenging to measure bite force, and its accuracy is influenced by a variety of variables, including the presence of pain and temporomandibular disorders, as well as gender, age, craniofacial morphology, and occlusal factors. In addition to these physiological variables, recording tools and methods are crucial in the assessment of biting force values. 6 These numbers can be utilised to quantitatively evaluate the masticatory performance due to the high association between masticatory performance and maximal bite force.[7]

Treatment of mandibular fractures has evolved significantly over the years. Earlier the treatment of mandibular fracture was based on reapproximation of the fractured segments and intermaxillary fixation using different techniques. The disadvantages associated with the technique of closed reduction and with the introduction of antibiotics in the surgical field, gave way for open reduction and fixation of fractures using different methods such as pin fixation, transosseous wire fixation, rigid fixation devices, compression plating, eccentric compression plating and lag screws. Many different materials and designs were used and tested for making appliances for fixation of mandible. Introduction of miniplates by Michelet (1973) and principles of miniplate osteosynthesis described by Champy et al (1978), was revolutionary in the management of maxillofacial trauma. Since then, the use of non-compression miniplates with monocortical screws has been the standard method of treatment for mandibular fracture management.[8,9]

The main objective of fracture treatment is to return the body to its natural form and function. As the maxillomandibular apparatus is concerned, the normal occlusion and efficiency of chewing would indicate return to normal form and function. However most of the studies in the literature have assessed the return of masticatory function subjectively while the bite force is a quantitative factor which indicates the efficiency of the masticatory system.

Previous studies measuring the bite force values have used various modalities like ability to lift the weight, instruments like strain gauge transducers, piezoelectric film, gnathodynamometer, quartz force transducer, force sensing resistors, mounted strain gauges and springs, electronic sensors, pressure sensitive films, etc.5 There are many limitations in use of such instruments like commercial availability, need for specialized computer software, high quality optical scanners and the cost. For this study we have customized a bite force recorder with the help from biomedical engineering department.There is little research on measuring bite force after surgically treating mandibular fractures.[7,10-14]

The purpose of this study is to evaluate the maximum voluntary bite force in patients with mandibular fracture treated by open reduction and internal fixation (ORIF) using miniplates.

AIM OF THE STUDY:

To evaluate the maximum bite force in patients with mandibular fracture treated by open reduction and internal fixation using miniplates.

OBJECTIVES OF THE STUDY:

- To measure the maximum voluntary bite force at various time interval in patients treated for mandibular fractures; with open reduction and internal fixation using miniplates,
- To determine the rate of recovery of bite force in the post- operative period,

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- To analyze the data against the control group at 3 month postoperatively.

SOURCE OF DATA

• The study was carried out in the Department of Oral and Maxillofacial surgery, karnavati school of dentistry, Gandhinagar, Gujarat.

• Study was conducted during the period of September 2015 to September 2018

• 25 patients with isolated mandibular fracture were included in the study group

• 60 healthy individuals whose age, gender and diet history matched with the individuals in

the study group served as the control group

INCLUSION CRITERIA FOR STUDY GROUP:

1. Patients diagnosed for isolated mandibular fractures.

2. Patients with age more than 18 years.

3. Patients having at least 20 teeth inclusive of molars.

4. Patients with minimal dental restorations.

5. Patients with Mandibular fracture involving the dentate segment.

6. patients with mandibular fractures who need open reduction and internal fixation.

MATERIALS AND METHOD

EXCLUSION CRITERIA

1. Patients having fractures of facial skeleton other than mandible concomitantly.

2. Comminuted fractures of mandible.

3. Fractures of mandible requiring closed reduction.

4. Edentulous patients.

5. Patients with neuromuscular disorders such as Parkinsonism, Myesthenia

gravis, Trigeminal neuralgia, Facial palsy, etc.

METHODOLOGY:

• Ethical clearance was obtained from the institutional review board

• Informed written consent was obtained from all the subjects participating in the study

The diagnosis of mandibular fractures was made based on a detailed clinical examination

and Orthopantomogram and/or CT scan

• A detailed case history was recorded

All the patients were given antibiotics and analgesics as necessary.

• Maxillary and mandibular arch bars were placed for all the patients in the study group

under local anesthesia using lignocaine with adrenaline (1:80000)

MATERIALS AND METHOD

• All the subjects in the study group were treated by open reduction and internal fixation of mandibular fractures using miniplates

• All the patients recovered uneventfully and were discharged on 2nd or 3rd postoperative day.

• Post-operative bite force was measured at time interval of 1 week, 4 weeks, 6weeks, 8

weeks, 10 weeks and 3 months post operatively following surgery.

• Bite force was measured using a customized bite force recorder.

• Bite force was also measured in 60 healthy individuals from control group.

• Armamentarium:

• The bite force recorder was developed and customized.

• The device was calibrated using different quantities of known weights. This ensured the

accuracy of the device and avoided the errors in recording.

• The bite force recorder consists of a battery operated monitor with a digital view box. This monitor was connected to the bite fork with a detachable switch. The bite fork

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consists of two plates of aluminum separated from each other

• The ends of the aluminum plates were covered with disposable silicon rubber caps to

ensure comfortable biting and sterility of the procedure.

• These aluminum plates are cleaned in between the two procedures with alcohol solution tomprevent cross contamination.

MATERIALS AND METHOD

Bite force measurements:

• The patients were asked to sit straight comfortably in a dental chair with a relaxed head

posture and the patient's Frankfort's horizontal plane approximately parallel to the floor.

• The bite fork of the device was held by the operator and patient was asked to bite with

maximum biting force possible, on the rubber caps of the bite fork.

• Patient was asked to bite 3 times in succession on the bite fork with the rest interval of 2

minutes in between. The highest reading was considered.

• This procedure is performed in three locations of dentition in right first molar region,

incisor region and left first molar region. The maximum reading amongst all three locations was considered as the maximum voluntary bite force of the patient and was recorded in the proforma.

For the subjects in control group, same procedure was performed at different times and

the highest reading was considered as the maximum voluntary bite force and was recorded.

Mandible is the largest and the strongest bone in the facial skeleton. Because of its prominence in the facial skeleton it is highly susceptible to injuries. Mandible is the most commonly fractured bone in the facial skeleton next only to the nasal bones followed by zygomatic bone and the mid facial skeleton.[2,37] Factors such as geographical location, culture, and socioeconomic status influence the causes and incidence of maxillofacial fractures. Although comparable, the aetiology and the incidence of mandibular fracture differ across the world.

The incidence of mandibular fracture is seen maximum in the age group between 20-40 years. The possible explanation to high incidence of mandibular fracture in this age group is people are very energetic, take part in physical activities, drive motor vehicles carelessly, reluctance to wear helmets do not follow traffic rules, and are more likely to be involved in altercations.[39,41,53] The mean age of population in our study was 31.24 years.

Frequency of mandibular fractures is far more in males as compared to females. Studies on the epidemiology of mandibular fractures show a male: female ratio in the range of 3:1 to 6.1:1.[1,4,41,49,50]Our study showed male preponderance in cases of mandible fracture. The ratio of male: female seen in our study is 7.3:1. 88% of the sample size was male population while females consisted of 12% of the sample size. This finding is consistent with many studies on mandibular and facial fractures.[45-48]

In our study out of 25 patients, 19 (76%) cases were of RTA, 4 (16%) cases of assault and 2 (8%) cases were of fall. A study done by Chandra Shekar and CVK Reddy between 1998 and 2002 evaluating 546 patients showed RTA to be the commonest cause of facial injuries.41 Similar studies in other developing countries have shown that the incidence of motorcycle crashes is responsible for about 45-65% cases of maxillofacial injuries.[53,57,58]

Parasymphysis (50%) was found to be the most commonly fractured site in our study followed by angle (28%), body (14%) and symphysis (8%) fractures. These findings are similar to studies done in the available literature.[1,6,45] On the contrary, few studies have mentioned angle or the condyle as the most commonly fractured sites in the mandible.[49]

In the present era, open reduction and internal fixation of mandibular fracture with miniplate osteosynthesis is considered as the standard treatment.[15,21,29,61]Closed reduction is usually preferred in the treatment of undisplaced fractures of the mandibular condyles.

The management of mandibular fractures using open reduction with internal fixation method has many advantages

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like early return to normal jaw function, normal nutrition, normal oral hygiene after few days, avoidance of airway problems, provides absolute stability which promotes primary bone healing, the bone fragments are reduced withprecision under direct visualization of the fracture sites, avoids detrimental effects onmasticatory muscles, does not require patient compliance or supervision and permits theinstitution of early physical therapy on the postoperative period. In comparison to IMF, itprovides more patient comfort, greater patient satisfaction, less myoatrophy and lesshospital stay.[62] Nalliah (2008), in a review of all hospitalizations in United States, foundthat[21],244 patients underwent facial fracture reduction as a primary procedure. The mostcommonly performed procedure was open reduction of mandibular fractures (52.2%).[44]

In our study all 25 patients were treated using open reduction and internal fixation under local anaesthesia using miniplate. Following open reduction and internal fixation of mandibular fracture, various treatment outcomes need to be measured to ascertain return

of normal form and function. Re-establishment of the bite force and thereby the masticatory efficiency is an essential factor.

Maximum bite force values vary greatly even among the normal individuals. Maximum bite force depends on many factors such as the neuromuscular coordination, age, gender, craniofacial morphology, temporomandibular joint, occlusal factors, presence of dental restorations, dietary habits, etc.[5,6] The bite force can significantly reduce following trauma to mandible.[7,10,12,16,22]

In this study, the maximum voluntary bite force was assessed in 25 patient who sustained isolated fractures of the mandible and who were treated by ORIF. A control group consisting of 60 healthy individuals whose demographic data matched with the patients in study group were assessed for the bite force and the values obtained in both the groups were compared. The mean value of maximum bite force in the control group of our study was found to be 108.04 kg at right molar, 68.05 kg at incisor region and 108.58 kg at left molar region. Among the patients in study group, bite force was evaluated using bite force measurement appliance at an interval of 1st week, 4th week, 6th week, 8th week. 10th week and 3 months postoperatively.

The wide range of bite force values as found by different investigators which are likely due to several factors such as, location of the bite force transducer (i.e. unilateral,bilateral, posterior or anterior), subjects may be reluctant to bite fully on metallic transducer due to fear of dental damage, pain etc, size of the transducer may distract the condyles excessively, flexibility of the transducer may contribute to subject's reluctance to bite maximally, dynamic responsiveness or accuracy of the transducer, sensitivity of the teeth muscle and temporomandibular joint. These difference in bite force measurement is due to various appliance used by the investigators. So the bias in bite force value was reduced by using single bite force measurement appliance, by single investigator for study.

Our study shows, significant reduction in bite force after mandibular fracture. The bite force improved gradually over the time in the post-operative period after surgical intervention. The bite force at the 1st week postoperative was found to be only 25.95% at right molar region, 45.38% at incisor region and 25.11% at left molar region when compared to control group. This bite force was increased upto level of 82.94% at right molar region, 87.07% at incisor region and 83.13% at left molar region at 3 months postoperative period. This increase in bite force values was found to be significant at each postoperative follow up period. However, the maximum bite force value even at the end of 3 months was significantly less as compared to the maximum bite force value in controls.

The result of our study were in consistent with the studies by Tate et al who found increased in bite force from 27.9% at 1 week to 52.73% at 6 weeks, and there was statistically significant reduction in bite force as compared to controls10, Gerlach et al who found maximum bite force improvement from 31% at 1 week to 58% at the end of 6 weeks.They found a significant drop in bite force values at 5th week postoperatively which wasnot seen in any other studies. Bite force values were found to be significantly less than controls till 4 weeks.12 Sonnenberg and Voelker used a compression plate for mandibular fracture treatment and showed that bite force value was 50% to that of controls at the end of 6 weeks.[12]

A study by Tharani et al shows bite force values at 1 week accounted for 23% that of controls. This value increased to

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30% in week 2, 40% in week 3, 44% in week 4, 58% in week 5 and 66% by the end of 6 weeks.[7] Frank dal santo et al their study on 10 male patients with isolated ZMC fracture, calculated the masseter muscle force based on maximum bite force values and EMG activity of muscles. Their results showed that the masseter muscle force slowly increased from preoperative values, but even at the end of 4weeks, it was well below that seen in control group.[16] A study by Reena Talwar et al inmandibular condylar process fractures showed that even at the end of 6 weeks, the maximum bite force values were less than half of that seen in control group, and showsstatistically significant reduction in maximum bite force values.[22]

The reduction in bite force after trauma can be explained based on various reasons. It can be related to different factors such as tactile impulses, pain and pressure perception in the periodontal ligament, the number of residual teeth and age owing to age related deterioration of dentition.[10,14,17] Direct trauma to the masticatory muscles during the event of injury can lead to inflammation of the muscle thereby reducing the activity of the muscle. The damage to the various perioral groups of muscles during the surgical treatment can also be one of the factors. Placing fixation hardware from an intra oral approach in angle fracture necessitates the masseter muscle and a portion of the temporalis muscle being stripped off from their attachment from the lateral border of mandible. Also, a transfacial trochar used for instrumentation may also damage the masseter muscle.[10]

It has been known for years that protective neuromuscular mechanism occurs throughout the body where selective components of the neuromuscular system are activated or deactivated to take off the forces acting on the damaged skeleton.[7,10-14] Findings of the study by Ellis E et al where unilateral condylar process fractures were examined using bite force and EMG. Working/ balancing EMG ratio was different in fracture and non fracture sides. 1.5 times more activity was noted in the muscles on the non fracture side as compared to that in fractured side. From this study, one can postulate that, changing the working /balancing EMG ratios is the body's defense mechanism to prevent loading of damaged part of the skeleton.[11]

Correlating with the findings of similar studies, this study proves that the maximum bite force significantly reduces following trauma to mandible and improves gradually over time following the treatment of fracture by open reduction and internal fixation. However, even at 3rd month the maximum bite force is much less compared to the control group.

Eichner et al reported much lower values at the time of function i.e. during mastication of food. The average biting force for each single power stroke while masticating was found to be 16.5 N for a cracker, 22.2 N for whole meal bread, 16.7 N for hard sausage and 34 N for bacon. Considering these findings, the recommendations provided by in vitro studies using 3-D models of mandible and applying maximum loads at different area simulating jaw function are over inflated. [9]These findings imply that, fixation requirements which are based on maximum voluntary biting force seen in non injured subjects are grossly overstated since the amount of maximum bite force generated in patient with fractured mandible is much less as compared to non injured subject and the actual bite force during the mandibular functions such as while chewing food would be much lesser.[10]

So the results of our study shows that post operative, after treatment of mandibular fracture with ORIF, the significant reduction in the maximum bite force was found as compared to the normal individuals and it implies that, a less amount of fixation hardware such as microplates or resorbable bone plates may be sufficient for fixation ofmandibular fractures.

The present study could open avenues 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. This study would evoke more inquisitiveness on evaluation of bite forces in various maxillofacial treatment procedures.Bite forces are a relatively underexplored area of maxillofacial surgery. With regard to trauma, the return to normal functional forces does not correspond to return of the maximum bite forces. In mandibular fractures, functional forces are restored in 4 to 6weeks and maximum bite forces in 12 weeks.

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SUMMARY and CONCLUSION

In this study a randomized control trial was carried out at Dept. of Oral and Maxillofacial Surgery, Karnavati School of dentistry to evaluate the maximum bite force in patient with mandibular fracture treated by open reduction and internal fixation using miniplates.Patients with isolated mandibular fracture were included in this study. The study group consisted of total 25 patients of which 22 (88%) were male and 3 (12%) were female with male to female ratio being 7.3:1. The mean age of the patients was 31.24 years with range being 20 years to 55 years. The control group was made up of 60 subjects from healthy population.

Maximum bite force was recorded using a standard protocol at various time intervals using a customized bite force recorder. The bite force in study group was recorded at 1stweek, 4th week, 6th week, 8th week, 10th week and 12th week postoperatively at right molar, incisor and left molar region. Maximum voluntary bite force was also recorded in a control group using the same bite force recorder. The mean value of maximum bite force in the control group of our study was 108.04 kg at right molar region, 68.05 kg at incisor region and 108.58 kg at left molar region.

The study shows gradual improvement in the value of maximum bite force over aperiod of time. The bite force at the 1st week postoperative was found to be only 25.95%at right molar region, 45.38% at incisor region and 25.11% at left molar region whencompared to control group. This bite force was increased upto level of 82.94% at rightmolar region, 87.07% at incisor region and 83.13% at left molar region at 3 months postoperative period. The bite force at various time periods in the study group wascompared to control group using unpaired t test and found to be significant ($p<0.05$).Increase in bite force value was found to be highly significant at each postoperative follow up period.

Results of the study is that, after mandibular fractures there is obvious damage to themasticatory apparatus and hence reduction in maximum bite force. The return of masticatory function improves gradually over a period of time. During the period of healing the damaged maxillofacial skeleton is protected from the masticatory forces by the muscle splinting mechanism of the body. The findings of reduced bite force after mandibular fracture needs to be considered while selecting the amount of fixation hardware required in treatment of mandibular fractures. Further in depth studies with more sample size, different methods of fixation and a longer follow up period are required to recommend the ideal fixation requirements in the treatment of mandibular fractures.

“In conclusion, let us welcome a new method of fixation offered for the treatmentof fractures, but we should be discriminating and critical at first and use it intelligently.Otherwise, failures may not only do harm to the patient, but may also bring disrepute tothe method, which it does not deserve.”- Waldron et al.

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