Bite Force Measurement in Mandibular Parasymphyseal Fractures: A Preliminary Clinical Study

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ABSTRACT

We measured the amount of bite force generated by patients treated for parasymphyseal fractures of the mandible by open reduction and internal fixation at various predetermined time intervals. Sixty volunteers ranging from 18 to 60 years old were selected as the control group. All measurements were made on a bite force measurement device with the head in an upright position and in an unsupported natural position. Bite forces were measured at the incisor and right and left molar regions. These bite forces were compared with six patients with isolated mandibular unilateral parasymphyseal fractures. All patients were operated using open reduction and internal fixation using two miniplates at the fracture site. In the volunteer group, bite forces ranged from 22 to 50 kg in the molar region and 3 to 27 kg in the incisor region. Mean adult healthy values (male and female) in the molar region were 36 kg and in the incisor region, 15 kg. In mandibular parasymphyseal fractures, incisor bite forces were reduced significantly when compared with the control group in the first 2 postoperative weeks and regained significantly thereafter till 4 to 6 weeks. Bite forces in the molar region took ~6 to 12 weeks to regain maximum bite forces when compared with the volunteer group. Restoration of functional bite forces was evident by 6 to 8 weeks. However, the restoration of maximum bite forces may require up to 12 weeks in parasymphyseal fractures.

KEYWORDS: Bite force, jaw fracture, parasymphyseal fracture, functional bite force

The treatment of mandibular fractures has been in a constant state of evolution with goals to restore function and premorbid occlusion. Guglielmo Salicetti in 1492¹ introduced the concept of maxillomandibular fixation, which was later popularized by Gilmer in 1887.² The concept of open reduction for fractures of the mandible was introduced by Buck³ using an iron loop, followed by Gilmer⁴ and Luhr.⁵ Champy et al described a novel and currently the most accepted concept of using noncompression monocortical plates in the

regions, referred to as “Champy’s lines of osteosynthesis.”⁶

Forces applied by the masticatory muscles in dental occlusion (i.e., bite force) following treatment of mandibular fractures have received little attention. The maximum voluntary bite force measurement in healthy male is of the order of 50 pounds in American population.⁷ This study focused on the period required for recovery of maximum bite force following treatment of mandibular parasymphyseal fractures. Bite forces generated by

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Figure 1 Bite force measurement appliance.

patients were measured postoperatively at various predetermined times. The data reported here concern maximum voluntary bite forces an individual could generate. The amount of forces used during functional activity (functional bite forces) is probably much less. These readings were compared with the forces generated by an appropriate control group.

A suitable bite force measurement appliance (Fig. 1) was fabricated to measure the maximum voluntary bite forces in our study, as it is not possible at present to measure the functional bite forces.

MATERIALS AND METHODS

Ethical committee approval was obtained prior to the commencement of the study, and written consent was obtained from all the cases.

Voluntary Control Group

The voluntary control group ($n = 60$) was divided into three groups based on age differential (18 to 30 years, 31 to 40 years, and 41 to 60 years) with each group having 20 volunteers (10 males and 10 females). Case selection included medically fit patients aged between 18 to 60 years with incisors and first molars intact bilaterally and with no history of jaw fractures or orthognathic surgeries. All measurements were made with the head in an upright position and in an unsupported natural position. Bite forces were measured at the incisor and right and left molar regions.

Exclusion criteria were medically compromised patients with extremes of ages, compromised dentition, and temporomandibular joint pathologies and patients with large restorations, carious or root canal-treated molars and incisors, any form of fixed prosthesis like porcelain crowns or bridges, implant-supported tooth replacement or removable prosthesis, open bite, and cross-bite. Patients with previous history of major reconstructive maxillofacial surgeries like grafting after

partial resection and those with disabilities were also excluded from the study.

Study Group (Patients with Parasymphyseal Fractures)

The sample size included six patients with unilateral parasymphyseal fracture alone. All were treated using open reduction and rigid internal fixation using two miniplates. Case selection criteria included medically fit patients between 18 and 60 years of age. All patients with adequate dentition to perform bite force measurements and willing to participate in the study were included.

Exclusion criteria were medically compromised patients with extremes of age or with other forms of open reduction and internal fixation (e.g., fixation with transosseous wiring, compression bone plates, etc.). Also excluded were patients with inadequate dentition to undergo bite force measurements and those who were unwilling to participate in the study. Patients with comminuted mandibular fractures, myofascial pain dysfunction syndrome, dentofacial deformities, or neurosensory deficits were not included.

Protocol

After thorough preoperative laboratory studies, preoperative imaging, and preoperative antibiotics, patients were taken for surgery. Patients were operated under general anesthesia with nasoendotracheal intubation. Maxillo-mandibular fixation was achieved with Erich arch bars using 24- and 26-gauge soft stainless steel wires. The parasymphyseal area was approached intraorally with a vestibular incision. Two miniplates (2.5-mm stainless steel) were placed: one at the inferior border with bicortical screws (2.5 mm diameter $\times$ 10 mm length) and the second plate, 3 to 5 mm above the first plate and fixed with monocortical screws (2.5 mm diameter $\times$ 6 mm length). In all cases, maxillomandibular fixation was released on the operation table itself. Arch bars were removed after 3 weeks.

The bite forces were measured at 1, 2, 4, 6, 8, 10, and 12 weeks postoperatively with the help of the bite force measurement appliance (Fig. 1). The measurements were obtained from the right molar, left molar, and incisor regions and tabulated for analysis.

RESULTS

In the volunteer group, bite forces ranged from ~ 22 to 50 kg in the molar region and from 3 to 27 kg in the incisor region. The mean adult healthy value (male and female) in the molar region was 36 kg, and in incisor region it was 15 kg (Fig. 2). Adult healthy Indian

Figure 2 Bite force in healthy volunteer group.

individuals in our study showed an average of 36.2 kg of bite forces in the right molar, 35.96 kg in the left molar, and 14.83 kg in the incisor region.

Females showed reduced bite forces when compared with males in those age groups (Table 1). Our study showed a trend of increased bite forces with increasing age in male patients, but this was not true in the female group.

In mandibular parasymphiseal fractures, incisor bite forces were reduced significantly when compared with the control group in first 2 postoperative weeks and regained significantly thereafter till 4 to 6 weeks. Bite forces in the molar region took ~6 to 12 weeks to regain maximum bite forces when compared with the volunteer group (Fig. 3).

Figure 3 Comparative analysis graph.

DISCUSSION

Our study 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. Females showed reduced bite forces when compared with males in similar age groups. Our study also showed a trend of increased bite forces with increasing age in males, but this was not true in females. The right and left molar regions did not show any significant differences in bite forces.

In cases of parasymphiseal fractures, bite forces were subnormal till 4 weeks, and maximum bite forces were restored by the 8 weeks. There was no significant gain in bite forces after 8 weeks (Table 1).

It is at present not possible to measure functional bite forces. Therefore, the return of maximum bite forces was used to assess the recovery of bite forces. Reasons for

Table 1 Bite Force Measurements of Patients with Parasymphiseal Fractures

Patient No.	1 Wk	2 Wk	4 Wk	6 Wk	8 Wk	10 Wk	12 Wk
1	LM = 10.2 RM = 10.4 I = NA	LM = 12.1 RM = 11.5 I = NA	LM = 19.0 RM = 18.7 I = NA	LM = 30.0 RM = 31.7 I = NA	LM = 32.5 RM = 33.2 I = NA	LM = 33.0 RM = 34.5 I = NA	LM = 34.7 RM = 35.0 I = NA
2	LM = 17.9 RM = 7.5 I = 5.8	LM = 23.0 RM = 18.7 I = 7.3	LM = 30.0 RM = 27.0 I = 10.5	LM = 31.2 RM = 30.0 I = 10.7	LM = 33.0 RM = 30.7 I = 12.0	LM = 33.2 RM = 31.0 I = 12.3	LM = 33.0 RM = 34.9 I = 12.2
3	LM = 18.6 RM = 21.5 I = 11.3	LM = 21.0 RM = 23.0 I = 13.0	LM = 30.6 RM = 29.1 I = 14.9	LM = 33.8 RM = 33.4 I = 16.1	LM = 34.9 RM = 36.8 I = 16.8	LM = 39.2 RM = 37.9 I = 16.6	LM = 42.9 RM = 42.6 I = 18.7
4	LM = 12.2 RM = 12.0 I = 2.6	LM = 16.3 RM = 16.4 I = 7.1	LM = 27.9 RM = 27.5 I = 7.6	LM = 34.3 RM = 34.8 I = 13.3	LM = 35.0 RM = 34.9 I = 14.0	LM = 36.8 RM = 36.3 I = 15.4	LM = 39.6 RM = 38.2 I = 16.2
5	LM = 6.4 RM = 8.4 I = 1.9	LM = 9.6 RM = 9.8 I = 4.6	LM = 27.0 RM = 26.3 I = 7.0	LM = 31.2 RM = 32.7 I = 8.7	LM = 30.9 RM = 32.5 I = 9.0	LM = 31.7 RM = 33.2 I = 20.4	LM = 36.1 RM = 33.5 I = 21.2
6	LM = 14.7 RM = 13.6 I = 3.2	LM = 17.8 RM = 20.9 I = 6.7	LM = 27.8 RM = 30.9 I = 12.1	LM = 33.2 RM = 34.6 I = 16.1	LM = 40.0 RM = 42.8 I = 18.7	LM = 47.1 RM = 50.4 I = 21.4	LM = 48.2 RM = 51.1 I = 21.6

All readings in kilograms. LM, Left molar, RM, right molar; I, incisor; NA, not applicable (not possible).

subnormal forces in mandibular fractures may be trauma to masseter and temporalis muscle intraoperatively and protective neuromuscular mechanism of masticatory system. It was also observed in our study that the patient's willingness to bite forcefully was also a major cause in obtaining subnormal forces. This is related to both mental attitude and comfort of the dentition. Some patients were afraid to use their jaw vigorously, especially in the first few weeks.

Our readings are similar to those elucidated by Tate et al⁷ for measurement of bite forces in patients treated for mandibular angle fractures. Their study suggested that molar bite force was significantly less in patients till postoperative week 6. Gerlach and Schwarz⁸ measured bite forces in patients for mandibular angle fractures treated with miniplate osteosynthesis through an intraoral approach with a single miniplate at the external oblique line of the mandible without postoperative maxillomandibular fixation. The study concluded that at postoperative week 1, only 31% of the maximal vertical loading found in the control group was registered, and these values increased to 58% at postoperative week 6.

Teenier et al⁹ studied the effects of local anesthesia on bite force generation and electromyographic activity, showing that there were no significant differences in the bite forces observed between the anesthetized and nonanesthetized sides, nor on the anesthetized side at different levels of anesthesia. They concluded that sensory information from the dentition and surrounding periodontium are not critical for modulating maximal bite forces or in recruitment of jaw muscles to generate maximal voluntary bite forces.

Dean¹⁰ performed a preliminary study of maximum voluntary bite force and jaw muscle efficacy in 84 patients who underwent orthognathic surgery for various dentofacial deformities and concluded that there was a reduced ability to generate occlusal forces in patients before surgery. A reduction in maximal occlusal force also attributed to reduced efficiency of jaw muscles. Dal Santo et al¹¹ stated that molar bite force on the fractured side in zygomatic complex fractures was significantly less than that on the unaffected side. They suggested that molar bite force was significantly less in patients as compared with the control group for several weeks after surgery.

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 of the parasymphiseal region, functional forces are restored in 4 to 6 weeks and maximum bite forces in 8 weeks.

REFERENCES

1. Spina AM, Marciani RD. Mandibular fractures. In: Fonseca RJ, ed. *Oral & Maxillofacial Surgery*. Vol. 3 (Trauma), 1st ed. Philadelphia: W.B. Saunders; 2000:85-86
2. Gilmer TL. A case of fractures of lower jaw with remarks on treatment. *Arch Dent* 1887;4:388
3. Buck G. Fracture of the lower jaw with replacement and interlocking of the fragments. *Annalist NY* 1846;1:245
4. Gilmer TL. Fractures of the inferior maxilla. *J Dent Sci* 1881;1:309
5. Luhr HG. Zur stabilen osteosynthese bei unterkeiferfrakturen. *Dtsch Zahnarzt Z* 1968;23:754
6. Champy M, Loddé JP, Schmitt R, Jaeger JH, Muster D. Mandibular osteosynthesis by miniature screwed plates via a buccal approach. *J Maxillofac Surg* 1978;6:14-21
7. Tate GS, Ellis E III, Throckmorton G. Bite forces in patients treated for mandibular angle fractures: implications for fixation recommendations. *J Oral Maxillofac Surg* 1994; 52:734-736
8. Gerlach KL, Schwarz A. Bite forces in patients after treatment of mandibular angle fractures with miniplate osteosynthesis according to Champy. *Int J Oral Maxillofac Surg* 2002; 31:345-348
9. Teenier TJ, Throckmorton G, Ellis E III. Effects of local anesthesia on bite force generation and electromyographic activity. *J Oral Maxillofac Surg* 1991;49:360-365
10. Dean J, Throckmorton G, Ellis E III, Sinn D. A preliminary study of maximum voluntary bite force and jaw muscle efficiency in preorthognathic surgery patients. *J Oral Maxillofac Surg* 1992;50:1284-1288
11. Dal Santo F, Ellis E III, Throckmorton GS. The effects of zygomatic complex fracture on masseteric muscle force. *J Oral Maxillofac Surg* 1992;50:791-799