Original Article

Indian Journal of Dental Education
Volume 10 Number 1, January - March 2017
DOI: https://dx.doi.org/10.21088/ijde.0974.6099.10117.3

Bite Force Evaluation in Mandibular Fractures Treated with Miniplates

B.C. Sikkerimath*, Shushma G.**

Abstract

Since the introduction of the Champy miniplate in treatment of mandibular fractures, the potential and effectiveness of this method has been demonstrated in many clinical studies. Inspite of the encouraging results some authors have raised doubts as to the functional stability of miniplates. The aim of this study is to evaluate load resistance of mandibular fractures treated with miniplate osteosynthesis using bite force recorder. 20 patients with mandibular fracture were selected and treated by open reduction and internal fixation using titanium conventional mini plates. The bite force measurements were performed pre-operatively and post-operatively at follow up intervals of 12th hour post-operatively, 1st week, 2nd week, 4th week and 6th week using bite force recorder. The maximum bite force increased from 11.62% at 12th hourly, 25.69% at 1 week, 34.17% at 2 weeks, 53.39% at 4 weeks and 64.34% at 6 weeks postoperatively. 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 6 weeks was significantly less as compared to the maximum bite force value in controls.

Keywords: Mandible Fracture; Miniplates; Champy's Osteosynthesis; Bite Force.

Introduction

The osteology of mandible, the muscular attachments and their influence and presence of developing or developed dentition play an important role in producing the inherent weakness of the mandible[1]. The contributing factors for compromised strength of mandible are the cantilevered nature of the angle region, constriction of the neck in the sub condylar region, presence of mental foramen and long socket in canine region [1,2].

The above quoted reasons can possibly explain the frequent incident of mandibular fracture during facial injuries. Considering its incidence, mandibular fracture is the second most commonly occurring fracture next to nasal bone when considering facial fractures. It is the tenth most commonly occurring fracture when considering the frequency of bone fractures of the whole body. Majority of mandibular fractures were found in males and it contributes to about 61% of all facial bone fractures. Mandibular fractures outnumbered zygomatic and maxillary fractures by a ratio of 6:2.1 respectively [1,2,3,4,].

Surgeons began to explore the concept of open reduction and internal fixation. Techniques used in orthopedic fracture management (Arbeitsgemeinschaft fur osteosynthesefragen / Association for study of internal fixation), were borrowed and applied to maxillofacial surgery. Various techniques like intraosseous wires, external pins, intramedullary pins and plates and screws were tried by various experts, [Roberts (1964), Battersby (1967), Becker (1974), in USA and Luhr (1960), Spiessl (1970) and Champy in Europe] in an attempt to overcome the disadvantages of intermaxillary fixation. From then the hardware available for treatment of mandibular fractures has been in a constant state of evolution and recently, designs like the 3-D plates and locking plates have been introduced in maxillofacial surgery as a new treatment modality [4,6,7,8]. The potential and effectiveness of Champy's miniplate

Author's Affiliation: *Professor and HOD, Dept of OMFS, P.M.N.M Dental College and Hospital, Bagalkot, Karnataka. **Resident, Dept of Dentistry, KIMS, Koppal Karnataka.

Reprints Requests: Shushma G., House # A 9, Doctors Quarters, Koppal District Hospital, Koppal-583231 Karnataka
E-mail: drshushmamattad@gmail.com

Received on 12.12.2016, **Accepted on** 28.12.2016

osteosynthesis in treatment of mandibular fractures has been demonstrated in many clinical studies [8]. Inspite of the encouraging results some authors have raised doubts as to the functional stability of miniplates. Further research is warranted to establish the efficacy of the system.

The normal bite force of the individual varies from 120 N to 800 N depending on age, sex, site and method of measurement [9,10]. Maximum voluntary bite force is an indicator of the functional state of the stomatognathic system, and its magnitude is the result of the combined action of the jaw elevator muscles modified by jaw biomechanics, their muscle cross sections, muscle sarcomere length and reflex mechanisms. In this way, the measurement of bite force can provide useful data for the evaluation of jaw function and activity [9,10].

Methodology

This study conducted in PMNM Dental College, Bagalkot, Karnataka. Forty individuals were selected for the study and were divided into two groups namely Group A and B. Group A (Control Group) consisted of 20 individuals with an age group between 20 to 50 years, who were not medically compromised, with full complement of teeth and who had no history of previous facial trauma. Group B (Study Group) consisted of 20 individuals of age group between 15 to 50 years, who were diagnosed to have mandibular fractures and are treated by open reduction and internal fixation, through an intra oral approach using titanium conventional mini plates and screws under local anesthesia. The bite force measurements were performed pre-operatively and post-operatively at follow up intervals of 12th hour post-operatively, 1st week, 2nd week, 4th week and 6th week using bite force recorder (Table 1).

Inclusion Criteria

- Mandibular fractures requiring open reduction with rigid internal fixation for treatment.
- Subject medically fit and willing to participate in this study.
- Symphysis and para-symphysis fracture of mandible

Exclusion Criteria

- Patients with systemic diseases contraindicated for local and general anesthesia.
- Patients with comminuted fracture.
- Patients with infection.
- Patients with associated bone pathology.
- Patients with compromised immunity.
- Patients with midface and dentoalveolar fractures of maxilla

After thorough preoperative laboratory studies and imaging, patients were taken up for surgery. Bite force were recorded preoperatively. Maxillomandibular fixation was achieved with Erich arch bars using stainless steel wires. The symphyseal and parasymphyseal area was approached intraorally with vestibular incision. The miniplates fixation done according to Champy's line of osteosynthesis, one miniplate at the inferior border and the second plate at 3 to 5 mm above the first plate. In all cases, inter-maxillomandibular fixation was released after the surgery (Image 1 & 2).

The patients were instructed for a semi solid diet for 1st four weeks. Follow ups were done at 1st week, 2nd week, 4th week and 6th week, during every follow up the patient was evaluated clinically and radiographically for occlusion, infection and plate stability. The bite force was recorded at anterior and posterior during postoperative 12th hourly, 1st week, 2nd week, 4th week and 6th week and were tabulated for analysis (Image 3).

Bite Force Device

A suitable mechanical structure using an elastic material is used to convert applied force into a deformation/deflection. The most common structure for such application is a fork shaped steel member. One or more strain gauges are cemented to the surface of each prong to sense the deformation caused by applied biting force. The strain gauges are sensors which convert the applied strain (deformation) into resistance. These strain gauges are used in a bridge circuit to convert variation in resistance to corresponding voltage. The voltage output is numerically correlated to the applied force by calibration process. Calibration is done with a standard universal testing machine (UTM) in the laboratory.

Results

This study had a male dominance (100%) and the major etiology was road traffic accident (90%), 5% was assault and 5% was fall. Out of 20 isolated mandibular fractures 10 were right sided (50%) and

6 left sided (30%) parasymphysis fractures and 4 were (20%) symphysis fracture.

The mean value of maximum bite force in the control group of our study was found to be 194.02+/-13.59 N.

Our study shows significant reduction in bite force of the patients in study group at the preoperative period. The bite force improved gradually over the time in the post-operative period after surgical intervention. The mean preoperative bite force value was 16.26 +/- 13.59 N. That is 11.49% of the bite force value in the control group. The mean bite force values at 12th hourly, 1 week, 2nd week, 4th week and 6th week postoperative time interval was 16.47+/-13.57 N, 58.46 +/- 11.35 N, 70.94+/-9.86N, 88.98+/-6.76N and 101.72+/-5.04N respectively. Hence the maximum bite force increased from 11.62% at a2th hourly, 25.69% at 1 week, 34.17% at 2 weeks, 53.39% at 4 weeks and 64.34% at 6 weeks postoperatively. 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 6 weeks was significantly less as compared to the maximum bite force value in controls (Table 2 & Figure 1).

Post operatively none of the patients had any complications. Pre existing anatomic form was restored, functional occlusion is maintained, clinical stability was achieved with no neurosensory deficits and facial esthetics was satisfactory.

Discussion

The pioneer in biomechanical studies Champy et al (1976), studied the photo elastic models of mandible and defined the lines of tension and compression. Based on these observations he outlined the ideal lines of osteosynthesis. When the mini plates were applied on these ideal lines of osteosynthesis, they were able to withstand a force of up to 600 to 1000N/mm. Their elastic limit of flexibility was 700 - 800 N/mm^2, and the rupture point was 950 - 1100 N/mm^2 which were substantially higher than the maximal masticatory force [4].

The results and observations based on different studies that considered the effects of maximum voluntary bite forces in non-injured subjects on fractured segments, in non-clinical models. It has been shown in many studies that the bite force remains significantly less, than those observed in non-injured individuals, even after 4 weeks following surgery [11,12]. At the end of first week after surgery, only 31% of normal vertical loading force is regained and at the end of six weeks it increases to 58% [13].

The reasons for lowered bite force values in jaw fractures is because of

- Pain
- Protective reflex mechanism known as "Muscle Splinting", that occurs following fracture of bones. The neuromuscular system is activated or de-activated accordingly to take forces off the damaged skeleton.
- Traumatic and surgical damage caused to the muscle during injury and surgery respectively [10,14].

Of the above three mentioned causes, neuromuscular adaptation is considered to be the most important contributing factor for the observed reduction in bite force [15]. It has also been shown that there is an early reduction in mandibular range of motions and distribution of masticatory muscle activity which assist in prevention of overloading of the fractured segments [16]. Hence fixation requirement based on maximum voluntary bite forces of non-injured patients are grossly inflated [17].

The recovery of maximum bite force was used to assess the stability of the mandibular fractures. Reasons for subnormal forces in mandibular fractures may be due to trauma to masseter and temporalis muscle intraoperatively and protective neuromuscular mechanism of masticatory system. It was also observed in the 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 [18]. Our study also experienced the same as patients were afraid to use jaw vigorously which is related to mental attitude of the patient and comfort inspite of detailed explanation to the patient about the usage.

Our readings are similar to those elucidated by Tate et al [12] 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 Schwarz [13] 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

Table 1: Maximal voluntary bite force in study group

Sl. No of Patients	Site	Bite Force Measurements in NEWTONS					
		PRE-OP	POST- OP				
			12TH HOUR	1ST WEEK	2ND WEEK	4TH WEEK	6TH WEEK
1	Anterior	19.9	19.4	43.2	58.9	98.6	131.1
	Left Posterior	49.0	49.2	100.03	112.6	257.8	294.2
	Right Posterior	55.1	54.9	101.9	118.8	264.9	310.9
2	Anterior	20.4	20.1	41.86	56.1	99.8	126.5
	Left Posterior	50.1	51.2	62.8	94.1	183.3	305.9
	Right Posterior	63.2	66.1	82.4	96.1	196.4	320.7
3	Anterior	27.1	25.8	39.8	57.8	89.9	99.9
	Left Posterior	53.8	52.8	175.5	225.5	294.2	304.0
	Right Posetrior	44.8	45.2	73.5	183.4	264.8	294.2
4	Anterior	26.2	26.8	42.9	59.0	96.2	103.0
	Left Posterior	57.8	58.1	119.6	161.8	273.6	341.4
	Right Posterior	48.9	49.6	117.7	159.8	269.7	336.3
5	Anterior	NA	NA	44.0	58.4	99.2	132.0
	Left Posterior	50.1	49.8	182.4	205.9	285.1	327.5
	Right Posterior	68.2	70.4	210.8	225.5	300.4	331.5
6	Anterior	19.9	19.4	38.1	49.2	88.7	94.2
	Left Posterior	59.4	60.5	198.9	236.9	301.7	346.7
	Right Postrior	68.9	70.2	206.8	251.8	310.1	352.8
7	Anterior	NA	NA	39.3	47.5	90.8	97.4
	Left Posterior	66.3	68.3	182.9	212.4	298.9	326.5
	Right Postrior	70.4	71.7	197.3	241.2	328.4	348.5
8	Anterior	NA	NA	42.8	45.2	72.4	99.1
	Left Posterior	57.3	58.4	176.2	224.8	304.0	352.8
	Right Postrior	62.3	63.2	199.8	262.9	318.1	360.1
9	Anterior	18.9	20.2	41.8	55.2	99.5	101.4
	Left Posterior	49.2	50.1	98.0	124.7	178.9	294.9
	Right Postrior	64.6	64.9	101.5	132.9	186.9	311.2
10	Anterior	29.4	29.9	42.8	53.2	97.0	104.5
	Left Posterior	53.2	52.8	179.5	232.9	286.2	312.0
	Right Postrior	48.3	47.9	93.9	191.9	272.9	289.8
11	Anterior	NA	NA	38.1	43.9	92.1	99.8
	Left Posterior	68.3	68.4	178.9	228.7	301.7	339.7
	Right Postrior	70.2	70.4	206.8	248.8	299.9	361.8
12	Anterior	23.8	24.1	44.2	57.3	102.5	123.4
	Left Posterior	53.2	53.5	188.4	215.9	279.1	317.4
	Right Posterior	55.5	56.0	212.8	232.9	298.6	329.9
13	Anterior	18.4	19.9	43.0	58.9	104.0	135.0
	Left Posterior	50.1	49.9	82.9	104.1	262.8	310.8
	Right Posterior	54.3	55.0	102.4	112.1	270.4	328.5
14	Anterior	17.9	18.4	40.9	57.8	99.9	149.2
	Left Posterior	50.2	51.2	109.5	169.9	268.6	361.4
	Right Posetrior	46.2	48.1	120.8	160.2	278.7	336.3
15	Anterior	27.9	28.4	42.0	58.3	100.3	140.5
	Left Posterior	53.9	53.4	165.6	228.9	304.2	314.0
	Right Posetrior	48.6	48.7	76.5	179.4	289.1	304.2
16	Anterior	28.4	29.1	42.8	56.8	102.8	134.3
	Left Posterior	50.2	51.0	118.6	158.8	263.6	351.4
	Right Posterior	48.9	49.2	116.7	161.8	259.7	336.3
17	Anterior	20.1	20.9	41.9	55.3	96.9	132.4
	Left Posterior	62.1	62.4	104.6	169.8	280.1	358.2
	Right Posterior	50.1	50.6	99.5	162.4	268.2	326.5
18	Anterior	18.5	19.2	40.4	57.2	102.9	148.0
	Left Posterior	58.3	59.2	99.4	141.9	303.6	341.4
	Right Posterior	53.9	52.3	87.8	159.8	299.4	336.3
19	Anterior	24.5	25.0	44.2	53.1	97.9	124.5
	Left Posterior	53.9	55.2	122.9	178.8	278.9	348.1
	Right Posterior	49.1	50.2	117.7	159.9	269.7	326.7
20	Anterior	22.4	21.8	41.78	54.96	99.64	76.5
	Left Posterior	45.1	44.8	69.9	95.4	187.3	289.3
	Right Posterior	46.8	47.1	82.3	134.9	244.6	297.9

Table 2: Comparison of study and control groups with respect to biting force (N) at different time intervals by t test

Time intervals	Study group		Control group		t-value	p-value
	Mean	Std. Dev.	Mean	Std. Dev.		
Pre-op	45.96	16.26	399.69	194.02	-13.5950	0.00001
12th hourly	46.43	16.47	399.69	194.02	-13.5754	0.00001
1st week	102.69	58.46	399.69	194.02	-11.3532	0.00001
2nd week	136.57	70.94	399.69	194.02	-9.8658	0.00001
4th week	213.43	88.98	399.69	194.02	-6.7594	0.00001
6th week	257.18	101.72	399.69	194.02	-5.0391	0.00001

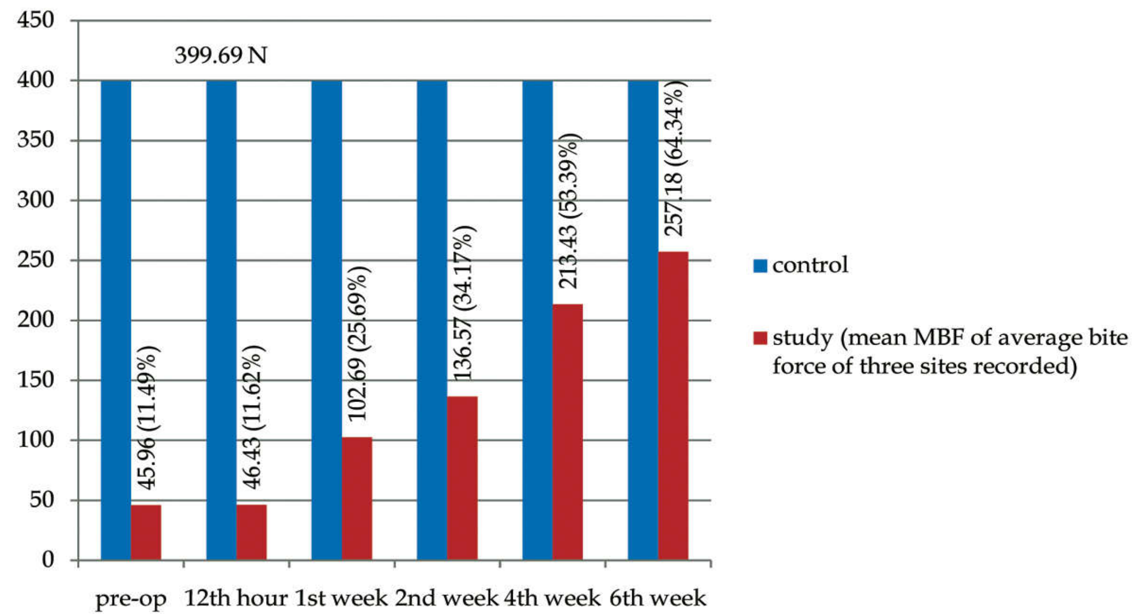

Fig. 1: Incresing bite force

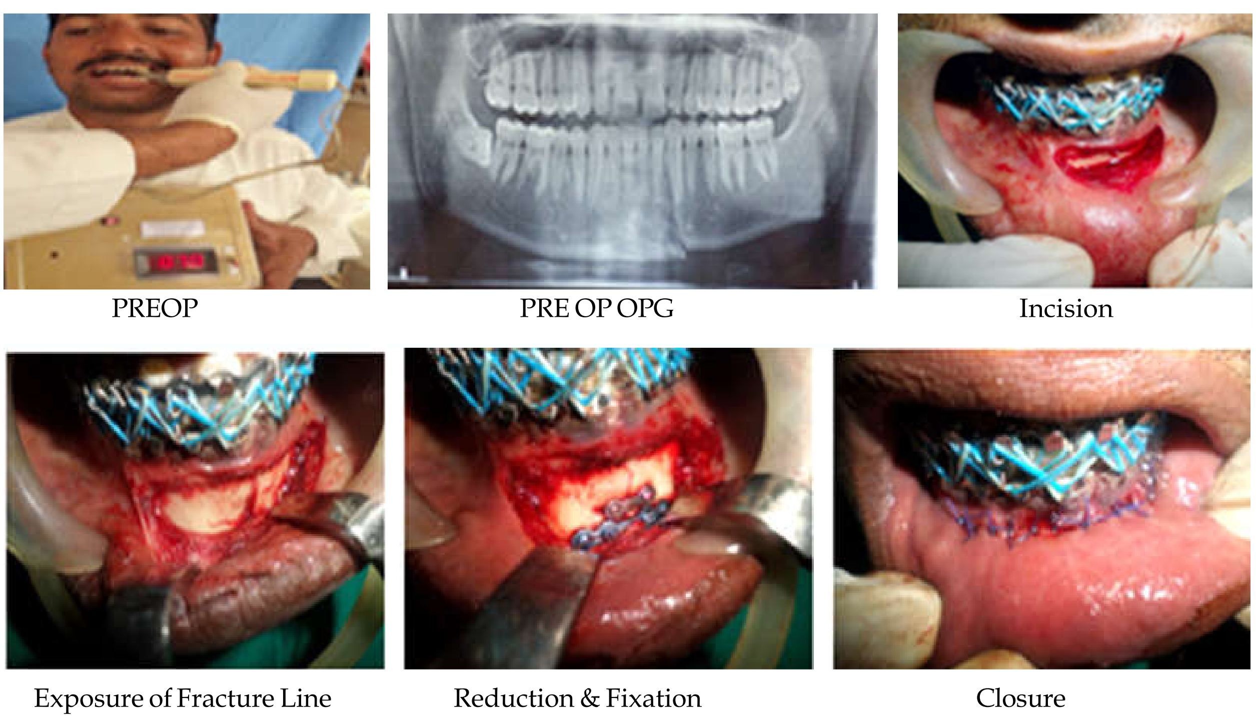

Image 1: Mandibular parasymphyseal (left) fracture

Image 2: Radiographic evaluation during the follow up

Image 3: Increasing bite force values

values increased to 58% at postoperative week 6.

Study by Kshirsagar et al shows that 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 [18].

Teenier et al 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 non-anesthetized 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 [19].

A study by Reena Talwar et al in mandibular condylar process fractures shows that even at the end of 6 weeks, the maximum bite force values were less than half of that seen in control group, and shows statistically significant reduction in maximum bite force values [20].

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 6th week the maximum bite force is much less compared to the control group.

At this point, it is important to note that, these values are the maximum forces one can generate and the actual bite force during the mandibular functions such as while chewing food would be much lesser. In vivo studies with different fixation techniques and calculating the actually applied bite force, will give us better understanding of the amount of force exerted on the healing mandible and its associated hardware. And hence, the fixation recommendations can be modified as necessary. The significant reduction in the maximum bite force following fractures of mandible as compared to the normal individuals imply that, a less amount of fixation hardware such as microplates or resorbable bone plates may be sufficient for fixation of mandibular fractures.

Conclusion

To achieve early functional mobility with assured stability in case of mandibular fractures, our findings suggest the use of miniplates, though a more extensive study with more number of patients and longer period of follow up is required to come to a definitive conclusion.

References

1. Fonseca and Walker: Textbook of Oral and Maxillofacial Trauma, Third edition, Volume I; Elsevier Saunders.
2. Rowe and Williams maxillofacial Injuries, 2nd Edition, Volume I; Churchill Livingstone, Edinburg London, 1994.
3. Adel R. Tawfilis et al: Facial trauma and mandibular fractures. Emedicine article, March 2006.
4. Kruger E and Schilli: Oral and Maxillofacial Traumatology; Volume I, II; Quintessence Publishing, 1982.
5. Jones J K, Van Sickels J E. Rigid fixation: A review of concepts and treatment of fractures. Oral Surgery, Oral Medicine, Oral Pathology. 1988; 65:13-18.
6. Ellis E. Rigid skeletal fixation of fractures. Advances in OMFS 1943-1993. Journal of Oral and Maxillofacial Surgery. 1993; 51:163-173.
7. Michelet and Deymes J. Osteosynthesis with miniaturized screwed plates in maxillofacial surgery. Journal of Oral and Maxillofacial Surgery. 1973; 1:79
8. Maxime Champy, Loddé JP, Schmitt R, Jaeger JH and Muster D. Mandibular osteosynthesis by miniature screwed plates via a buccal approach. Journal of Oral and Maxillofacial Surgery. 1978 Feb; 6(1):14-21.
9. Varga S, Spalj S, Milesovic S, Mestrovic S, Slaj M. Maximum voluntary molar bite force in subjects with normal occlusion. European Journal of Orthodontics. 2011; 33:427-433.
10. Hagberg C. Assessments of bite force: A Review. Journal of Craniomandibular Disorders: Facial & Oral pain 1987; 1(3).
11. Santo FD, Ellis E and Thockmorton GS. The effects of zygomatic complex fracture on masseteric muscle force. Journal of Oral and Maxillofacial Surgery. 1992; 50:791-799.
12. Tate GS, Ellis E and Thockmorton GS: Bite force in patients treated for mandible angle fractures. Implications for rigid fixation. Journal of Oral and Maxillofacial Surgery. 1994; 52:734-736.
13. Gerlach KL, Schwarz A. Bite forces in patients after treatment of Mandibular angle fractures with miniplate osteosynthesis according to Champy. International Journal of Oral and Maxillofacial Surgery. 2002; 31:345–348.
14. Gupta A, Singh V, Mohammad S. Bite force evaluation of mandibular fractures treated with microplates and miniplates: Journal of oral and maxillofacial surgery 2012;70:1903-1908.
15. Ellis III E and Thockmorton GS. Bite Forces after Open or Closed Treatment of Mandibular Condylar Process Fractures. Journal of Oral and Maxillofacial Surgery. 2001; 59:389-395.
16. Hidaka O, Iwasaki M, Saito M and Morimoto T. Influence of clenching intensity on bite force balance, occlusal contact area, and average bite pressure. Journal of dental research. 1999 Jul; 78(7):1336-44.

17. Tate GS, Ellis E and Thockmorton GS: Bite force in patients treated for mandible angle fractures. Implications for rigid fixation. Journal of Oral and Maxillofacial Surgery. 1994; 52:734-736.

18. Kshirsagar R, Jaggi N, Halli R. Bite force measurement in mandibular parasymphyseal fractures: A preliminary study. Craniomaxillofacial Trauma Reconstruction. 2011; 4:241-244.

19. Teenier T, Thockmorton G, Ellis E. Effects of local anesthesia on bite force generation and electromyographic activity. Journal of oral and maxillofacial surgery. 1991; 49:360-365.

20. Talwar RM, Ellis E and Thockmorton GS. Adaptations of the Masticatory System After Bilateral Fractures of the Mandibular Condylar Process. Journal of Oral and Maxillofacial Surgery. 1998; 56:430-439.