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Comparison Between Maximum Bite Force on First Molar with Prosthesis and Contralateral First Molar Without Prosthesis

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ABSTRACT

Background: Bite force is an indicator of the functional state of the masticatory system that results from the action of jaw elevator muscles modified by the craniomandibular biomechanics. Bite force measurement is essential in dental treatment as an extreme bite force on tooth may affect health of periodontium and increase risk of prosthesis fracture. A patient with low biting force may be helpful for the successful long-term outcome of prosthesis. A variety of devices has been used to record human bite force. Nowadays, sensitive electronic devices are used those are both accurate and precise enough. Recently, T-scan has been more popular to record the pattern of occlusion. The T-scan system precisely and dynamically records the occlusal contact time, force, and area in percentage. T-scan identify both force and timing which are the most fundamental parameters for measuring occlusion. The present study was designed to compare maximum bite force on first molar with prosthesis and contralateral first molar without prosthesis by using T-scan.

Objectives: To compare maximum bite force (MBF) on first molar with prosthesis and contralateral first molar without prosthesis.

Materials and Methods: This quasi-experimental type study was conducted in the Department of Prosthodontics, BSMMU. The patients were selected by a consecutive sampling technique, requiring permanent restoration in endodontically treated first molar on one side and natural first molar on contralateral side. The selected tooth was prepared for full veneer crown following standard procedure with armamentarium. Symptomless patients up to 3 months were measured bite force on cemented prosthesis and contralateral natural tooth. Bite force was measured with T-scan for three times with 30 sec interval and highest value was recorded in a data collection sheet for each patient to compare maximum bite force on first molar with prosthesis and contralateral first molar without prosthesis in the same patient.

Result: The maximum bite force at the first molar without prosthesis was 14.30 ±4.2% and first molar with prosthesis was 12.05 ±3.55%. Tooth without prosthesis maximum bite force was significantly more than the tooth with prosthesis.

Conclusion: Maximum bite force was significantly higher in tooth without prosthesis than the tooth with prosthesis. The difference of maximum bite force was not statistically significant in relation to gender, age and BMI.

INTRODUCTION

The bite force is the coordination of different components of the masticatory system. Bite force is one indicator of the functional state of the masticatory system that results from the action of jaw elevator muscles modified by the craniomandibular biomechanics. [1]

Bite force magnitude is directly dependent on the number of natural teeth i.e, increasing the number of teeth increase bite force[2].Chewing efficiency depends on many factors, such as occlusal contact, bite force, and masticatory muscle. The maximum bite force is the most reliable index of bite force, and it is used to assess the functional status of the masticatory system.[3]

Bite force measurement has been widely used to understand the biomechanics of masticatory muscles and outcomes of prosthodontic treatments. The bite force is significant for the diagnosis and treatment of dysfunction and behavior of the stomatognathic system.[4] Bite force measurement is essential when planning dental treatment. Some patients can generate extreme bite force that may affect health of periodontium and increase the risk of prosthesis fracture. A patient with low biting force may be helpful for the successful long-term outcome of prosthesis[5]

Two methods can measure bite force. One is Direct, by placing a suitable load transfer tool between the dental arches, and another is indirect, using physiological variables related to the masticatory force [4](Amid et al. 2018). Several factors influence the direct measurements of the bite force. Different investigators found a wide range of maximum bite force values. The variation in bite force values depends on the anatomical and physiologic characteristics of the subjects. Accuracy and precision of the bite force levels are affected by the bite force recording system.[6]

The measurement of bite force is helpful to evaluate the jaw muscle function and assess the prosthesis performance. These measurements are complicated, and the reliability of the result depends on several factors, such as craniofacial morphology, age, sex, periodontal support of teeth, temporomandibular disorders, presence of pain, and dental status.

Increased bite force values with increasing age, height, weight, and body mass index (BMI)[7, 8] have been observed by different researchers. However, Braun et al.[9]have reported low correlation between bite force and body variables. Higher bite force in male than female also reported by some authors.[10, 11]

In the case of periodontal support of teeth, when force exerts during mastication, the masticatory muscles are controlled by a mechanoreceptor of the periodontal ligament. Reduced periodontal support may decrease the threshold level of the mechanoreceptor function. This condition may change the bite force. Biting ability with healthy periodontium is significantly higher than chronic periodontitis . [12]

A variety of devices with different design and working principle has been used to record human bite force. The earlier devices were mechanical. Borelli built the first device in 1681. It was called a gnathodynamometer.[13] Nowadays, sensitive electronic devices are used in most of the bite force devices. Such devices are both accurate and precise enough for common load measuring purposes. Most of the devices can record a wide range of force (50-800 N) with accuracy (10 N) and precision (80%) .[14]The GM10 force gauge consists of a hydraulic pressure gauge with a biting element made of a vinyl material, covered with polyethylene tube called a disposable occlusal cap.[15]The most widely accepted recording device is the strain-gauge bite force transducer and is available in different heights and widths. Another recording device is the dental prescale system which consists of a horse-shoe-shaped bite foil of a pressure-sensitive film and a computerized scanning system for analysis of the load. [6]

Recently, T-scan has been more popular to record the pattern of occlusion. The T-scan system precisely and dynamically records the occlusal contact time, force, and area using a thin, flexible, pressure-sensitive bite transducer embedded in a dental arch-shaped recording sensor.[16]Articulating paper is the most commonly used diagnostic tool in dentistry. It highlights the occlusal contact point between maxillary and mandibular teeth, and the size of the mark represents the contact is heavy or light. Articulating paper can not quantify their intensity accurately and magnitude of the occlusal force.[17] T-scan identify both force and timing two of the most fundamental parameters for measuring occlusion.

Evaluation of bite force is a prime concern for a successful prosthesis with a survival rate. The present study was designed to compare the maximum bite force on first molar with prosthesis and contralateral first molar without prosthesis by using T-scan to evaluate the maximum bite force and to determine whether a relationship exists between the maximum bite force and the person's gender, age, and body mass index (BMI).

MATERIALS AND METHODS

This quasi-experimental type study was carried out in the Department of Prosthodontics, Faculty of Dentistry, Bangabandhu Sheikh Mujib Medical University. Dhaka. Bangladesh from April 2021 to October 2021.

A study sample was chosen that required a full veneer crown on endodontically treated first molar teeth selected from regularly attending patients at the Department of Prosthodontics, Faculty of Dentistry, Bangabandhu Sheikh Mujib Medical University, Shahbag,Dhaka-1000, Bangladesh. The study included 37 samples.

Consecutive sampling technique was used to select the cases for this study. All the available subjects were picked up who was met the preset inclusion criteria set for this study till the desired sample size was reached. It was ensured more representativeness of the selected sample. The selected endodontically treated tooth was examined and isolated to follow the standard principles of the tooth preparation for a full veneer crown. Then bite force was measured bilaterally at the molar region.

Study Procedure

Equipment's used for this study

Well illuminated dental chair

Dental mirror, twizer, caries explorer, dental cheek retractor.

T-Scan (Software version 10, Tekscan. Inc. South Boston, MA 02127)

Laptop.

Printer.

Patient selection and preparation

The patient was selected by thorough medical history, dental history, clinical examination, and periapical radiological examination and as per inclusion and exclusion criteria set for this study.

Diagnosis and treatment plan

The selected endodontically treated tooth was examined and isolated to follow the standard principles of the tooth preparation for a full veneer crown. Then bite force was measured bilaterally at the molar region.

Step by step tooth preparation procedure

The first permanent restoration of the selected tooth was performed with light cure composite resin as the mouth preparation phase of treatment. Tissue displacement was commonly obtained for adequate access to the prepared tooth to expose all necessary surfaces. This was achieved by mechanical means, i.e., looping the retraction cord around the tooth and gently pushing it into the sulcus with a cord packer before the tooth preparation. After preparation, if needed, the second (larger diameter) cord was used, saturating with astringent placed on top to achieve lateral tissue displacement. It was removed before making the impression.

Occlusal reduction :

Approximately 1.8 mm deep, three depth grooves were placed in the central, mesial and distal fossa and were connected so that a channel created the length of central groove and extended into the mesial and distal marginal ridge. About 2 mm of occlusal clearance was produced with round-end tapered diamond. Half of the occlusal reduction was completed at a time, so the other half was maintained as a reference. The functional cusp was beveled.

Facial reduction :

Approximately 0.8 mm deep, three depth grooves were placed, one in the center of the facial surface and one in the mesiofacial and distofacial line angels. About 1 mm facial reduction was produced .The reduction was made into two plane: the cervical portion was parallel to the long axis of the tooth, and the occlusal part followed the normal facial contour. The chamfer margin was created with round end tapered diamond and extend well into the proximal embrassures when viewed from the occlusal side.

Axial reduction of proximal and lingual surface :

About 0.8 mm deep depth grooves were placed on the lingual surface. About 1 mm reduction was made with round end tapered diamond. The proximal axial reduction was started with a short needle diamond without nicking adjacent teeth. The instrumention was done with ups and down and faciolingual motion.

Axial walls were made convergence slightly from occlusal. The approximately 6-degree taper was maintained between opposing axial walls.

Finish line preparation :

A smooth, distinct and continuous chamfer finish line about 1 mm width was provided. It was prepared using a round-ended tapered diamond. A vertical resistance was felt while checking with a tip of explorer.

Finishing:

All the prepeared tooth surfsces were smoothened using finishing stone. Any remaining sharp line angles and point angles were rounded with a slow-speed handpiece to prevent wedging action that might cause a fracture.

Impression making:

An elastomeric impression material, e.g., polyvinyl siloxane, single step double mix technique, was used here. At first perforated stock tray was tried into the patient's mouth for proper fit. After isolation, heavy body (putty) impression material kneaded adequately with both hands and loaded on the tray. At the same time, syringe material (light body) was injected over the heavy body and prepared tooth side after removing the retraction cord. Then the filled tray was inserted into the patient's mouth. The tray material was forced the syringe material to adapt to the prepared tissue. The manufacturers recommendation for maximum working time and minimum setting time was followed. After removing from the patient's mouth, the impression was immediately rinsed with running tap water and was disinfected by dipping in 2% glutaraldehyde for 10 minutes. Properly adjusted provisional restoration was luted to the prepared tooth. The cast was poured with type III die stone. Die was equipped with standard laboratory method, and trimming was done.

Laboratory procedure

A subsequent laboratory procedures were performed for full veneer crown as per the standard methods.

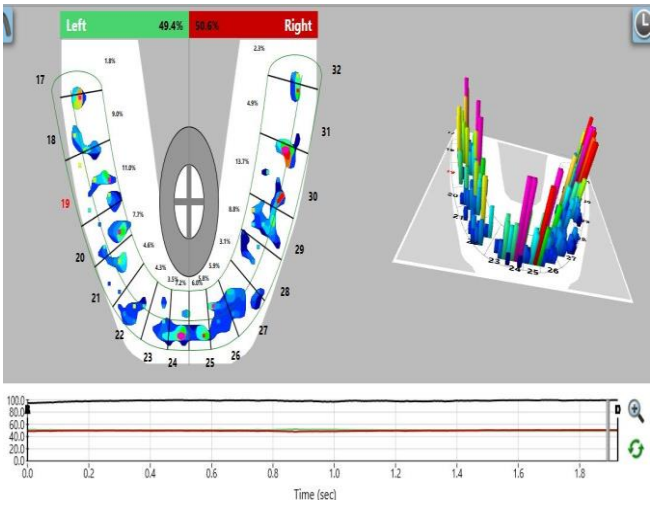
Cementation

Cementation was done, maintaining all the required procedures with type-1 Glass ionomer cement. Excess cement material was carefully removed and occlusion adjusted.

Instructions

Oral hygiene instructions were given to the patients for avoiding hard foods such as betel nut, sugarcane to prevent the restoration from fracture. The use of dental floss was advised. Each patient was requested and advised to attend the recall visits for proper evaluation of the clinical outcomes of the crowns.

Bite force recording procedure



Bite force was measured bilaterally at the first molar region. The recording procedure was performed with manufacturers' instructions. Patients were asked to sit upright in a dental chair to avoid the effect of head posture. Patients were previously trained to close their mouth in maximum intercuspation. A sensor was inserted intraorally between the dental arches with the midline of the incisors. The patient was then asked to bite on the sensor in the maximum intercuspal position. When occlusal contact appeared on the screen, the button on the handle was pressed. The resultant data was displayed as a force snapshot or as a continuous force movie of the entire occlusal contact event in two or three dimensions. Bite force was measured three times with 30-sec interval, and the highest value was recorded for each patient to compare maximum bite force on the first molar with fixed prosthesis and contralateral natural first molar in the same patient. All collected data were recorded in a data collection sheet.

OPERATIONAL DEFINITIONS

Fixed prostheses: Fixed dental prostheses are used to replace missing or damaged teeth that the patient can not remove.

Full veneer crown: A full veneer crown is a restoration provided to the patient; the crown will cover all the coronal tooth surfaces that are mesial, distal, buccal, lingual, and occlusal or incisal.

First molar with prosthesis: The fixed prosthesis that was fabricated and cemented on an endodontically treated first molar.

First molar without prosthesis: The first molar which healthy, was unaltered, and free of large filling, caries, and root canal treatment.

Endodontically treated teeth: The teeth from which pulp, composed of the blood vessel and nerve are removed and inside of the teeth will be cleaned and sealed and need to restore a coronal portion of teeth with full veneer crown.

Bite force: The pressure which is exerted on the teeth during biting.

T scan: T scan is a device that is used to record digital occlusal analysis systems. This device gives accurate 2D and 3D re-presentation of bite force with timing information relative to dental occlusion.

Stomatognathic system: It's an anatomical system comprising the teeth, jaws, and associated soft tissues.

RESULTS

In this study, the comparison between maximum bite force on first molar with prosthesis and contralateral first molar without prosthesis was evaluated in relation to age, sex, BMI by using paired T test.

22 of the patients (59%) were male and 15were female (41%). In this study, the age range was 20-67 years. The highest number of patients participated in this study were from 20-29 (48.6%) years age group. In distribution of patients by BMI types, 43% (16 patients) were normal weight, 43% (16 patients) were overweight, 5.5% (2 patients) were underweight, and 8% (3 patients) were obese.

Comparison between maximum bite force on first molar with prosthesis and contralateral first molar without prosthesis has been tabulated in Table 1. Paired T test was done. The result shows significant difference (P value<0.05).

Table1: Comparison between maximum bite force on first molar with prosthesis and contralateral first molar without prosthesis.

Bite Force		t value	P value
Tooth with prosthesis	Tooth without prosthesis	3.261	0.002
(Mean ± SD)	(Mean ± SD)		
12.056 ±3.554	14.302 ± 4.204		

Significant p value (<0.05)
Statistical analysis was done by Paired T test.

Comparison between maximum bite force on first molar with prosthesis and contralateral first molar without prosthesis according to gender has been shown in Table 2. No significance difference of maximum bite force was found in between male and female (p value >0.05).

Table2: Comparison between maximum bite force on first molar with prosthesis and contralateral first molar without prosthesis according to gender.

Gender	Bite Force		t value	P value
	Tooth with prosthesis (Mean ± SD)	Tooth without prosthesis (Mean ± SD)		
Male	12.418±3.084	14.805±3.952	2.669	0.064
Female	11.527±4.208	13.567±4.587	1.828	0.089

Significant p value (<0.05)
Statistical analysis was done by Paired T test.

Also, no significance difference of maximum bite force was observed in different age groups (Table 3).

Table3: Comparison between maximum bite force on first molar with prosthesis and contralateral first molar without prosthesis according to age.

Age group (In years)	Bite Force		P value
	Tooth with prosthesis (Mean ± SD)	Tooth without prosthesis (Mean ± SD)	
20-29	10.094 ±3.461	13.105 ±4.862	0.095
30-39	12.016 ±1.891	13.983 ±2.601	0.170
40-49	14.480 ±2.190	14.760 ±2.662	0.743
50-59	14.425 ±2.559	19.300 ±2.782	0.081
60-69	15.550 ±2.857	15.600 ±2.672	0.691

Significant p value (<0.05)
Statistical analysis was done by Paired T test

Table 4 showing comparison between maximum bite force on first molar with prosthesis and contralateral first molar without prosthesis according to BMI. No Significant difference of maximum bite force was found in different types of BMI (p value >0.05).

Table4: Comparison between maximum bite force on first molar with prosthesis and contralateral first molar without prosthesis according to BMI.

BMI	Bite Force		t value	P value
	Tooth with prosthesis (Mean ± SD)	Tooth without prosthesis (Mean ± SD)		

Under weight	12.85±0.636	15.75±5.727	-.644	0.636
Normal weight	10.37±3.468	13.27±5.213	2.601	0.080
Over weight	12.65±2.610	15.50±3.291	3.554	0.006
Obese	15.40±3.724	14.33±3.280	-.415	0.718

Significant p value (<0.05)
Statistical analysis was done by Paired T test.

DISCUSSION

The successful outcome of a dental prosthesis depends on the maximum bite force. Optimum bite force helps to preserve health of periodontium as well as longevity of the prosthesis.

The measurement of bite force is useful in evaluating muscle function and is also an adjunct in assessing the performance of prosthesis. Measurements related to bite force are difficult to detect and the reliability of the result depends on large number of factors, such as gender, age, craniofacial morphology, occlusal factors, presence of pain, and temporomandibular disorder. Apart from these physiological factors, recording devices and techniques play major role and are important factors in bite pressure measurement. To evaluate bite pressure, various techniques and devices are utilized including portable hydraulic pressure gauges, the bite fork, force sensing resistors, strain gauge transducers, pressurized rubber tube, foil transducers, pressure-sensitive sheets, and the gnathodynamometer.[18]

In this study, tooth without prosthesis maximum bite force was significantly higher than tooth with prosthesis. Patients feel discomfort to chew on the tooth with prosthesis side and psychologically patients chew more frequently on the tooth without prosthesis side than the tooth with prosthesis side. Gupta et al. [18] and Al-Zarea[19]stated that MBF of tooth without prosthesis was significantly higher than tooth with prosthesis which was similar with the current study.

In the present study, the MBF of tooth with prosthesis was (12.05±3.55%) which was less than the tooth without prosthesis (14.302 ± 4.204%). Al-Zarea[19] stated that the MBF of tooth with prosthesis was 580.9±74.3N that was less than the tooth without prosthesis MBF. This difference could be due to use of different devices, different type of prosthesis and other patients as control. In this study contralateral side of the jaw of the same patient was used as control.

In the present study, MBF of tooth without prosthesis was 14.30±4.20%. According to Al-Zarea[19]the MBF of tooth without prosthesis was 596.2±76.3N. The difference could be due to the use of different devices with different biting elements. Populations from different racial backgrounds could have different bite forces as a result of different eating habit, body features and life styles. Singhal et el. also found similar result in their study. [20]

The detected difference between implant treated and the natural dentition sides could have been influenced by the chewing side preference as implant side was edentulous for longer time. [21, 22]Furthermore, the potential of jaw flexure as well as variations in muscle tonicity during unilaterally closing down on hard objects might potentially affect the recorded bite force value. [20]

Although bite force values were different between dentate and treated sides, this difference might be considered clinically unimportant because the bite force at both sides is more than what is required for sufficient mastication and chewing in humans. [7, 8, 23, 24]

In the present study, male reported higher maximum bite force than female but the difference was statistically nonsignificant. The maximum bite force of tooth with prosthesis was 12.41±3.08% for male and 11.52±4.20% for female (table 2). Male reported higher maximum bite force than the female and the difference was statistically nonsignificant. Abu Alhaija et al.[7]found no significant difference between men and women regarding the MBF which was similar with the current study. Koc et al.[25]. Bonakdarchain et al.[26] stated that men had statistically higher maximum bite force than women. The reasons of this difference may be due to less sample size and decrease number of female patients.

No significance difference of maximum bite force was found in different age groups. Koc et al.[25]found that maximum bite force was higher in the senior age group than the younger age group which was not similar with the current study. The reasons of this difference may be due to the most of the patients were in 20-29 years of age group.

In this study, no significant difference of maximum bite force was found in different types of BMI. This finding is in agreement with the results of other studie].[7, 27, 28]Al-Zarea[19]demonstrated a significant relationship between BMI and MBF. Koc et al. [25]found no correlation between BMI and maximum bite force which was similar with the current study.

CONCLUSION

According to the results of this study, it can be concluded that maximum bite force was significantly higher in tooth without prosthesis than the tooth with prosthesis. The difference of maximum bite force was not statistically significant in relation to gender, age and BMI.

BIBLIOGRAPHY

1. Bakke M. Bite force and occlusion. Semin Orthod. 2006;12:120–126.
2. Ebeid A and El-Etreby A. The Influence of Biting Force on the Strain Induced Within Posterior Zirconia Three-Unit FPD Fabricated with Two Different Veneering Techniques. Egyptian Dental Journal. 2015: 61(1);93-100.
3. Manzon L, Vozza I, Poli O. Bite Force in Elderly with Full Natural Dentition and Different Rehabilitation Prosthesis. Int J Environ Res Public Health. 2021 Feb 3;18(4):1424.
4. Amid R, Ebrahimi N, Kadkhodazadeh M, Mirakhori M, Mehrinejad P, Nematzadeh F, Dehnavi F. New Device to Measurement of Maximum Bite Force. J Dent Oral Res 2018;2(1):4-7.
5. Flanagan D. Bite force and dental implant treatment: a short review. Med Devices (Auckl). 2017 Jun 27;10:141-148.

6. Koc D, Dogan A, Bek B. Bite force and influential factors on bite force measurements: a literature review. Eur J Dent. 2010 Apr;4(2):223-32.
7. Abu Alhaija ES, Al Zo'ubi IA, Al Rousan ME, et al. Maximal occlusal bite forces in Jordanian individuals with different dentofacial vertical skeletal patterns. Eur J Orthod. 2010;32:71–77.
8. Shiau YY, Wang JS. The effects of dental condition on hand strength and maximum bite force. Cranio. 1993;11:48–54.
9. Braun S, Bantleon HP, Hnat WP, et al. A study of bite force, part 2. Relationship to various cephalometric measurement. *Angle Orthod. 1995;65:373–377.*
10. Waltimo A, Könönen M. A novel bite force recorder and maximal isometric bite force values for healthy young adults. Scand J Dent Res. 1993 Jun;101(3):171-5.
11. Shinogaya T, Bakke M, Thomsen CE, Vilmann A, Sodeyama A, Matsumoto M. Effects of ethnicity, gender and age on clenching force and load distribution. Clin Oral Investig. 2001 Mar;5(1):63-8.
12. Alkan A, Keskiner I, Arici S, Sato S. The effect of periodontitis on biting abilities. J Periodontol. 2006 Aug;77(8):1442-5.
13. Ortuğ G. A new device for measuring mastication force (Gnathodynamometer). Ann Anat. 2002 Jul;184(4):393-6.
14. Verma TP, Kumathalli KI, Jain V, Kumar R. Bite Force Recording Devices - A Review. J Clin Diagn Res. 2017 Sep;11(9):ZE01-ZE05.
15. Varga S, Spalj S, LapterVarga M, Anic Milosevic S, Mestrovic S, Slaj M. Maximum voluntary molar bite force in subjects with normal occlusion. Eur J Orthod. 2011 Aug;33(4):427-33.
16. Pyakurel H. Mechanism, accuracy and application of T-Scan System in dentistry-A review. JNDA. 2013:13(1); 9-13.
17. Bozhkova TP. The T-SCAN System in Evaluating Occlusal Contacts. Folia Med (Plovdiv). 2016 Apr-Jun;58(2):122-30.
18. Gupta N, Poosala D, Sinha N, Aditya SV, Reddy GV. Analysis of bite force in patients with natural teeth versus fixed partial denture a within subject comparison. J Dent Sci Res 2015;5:27-31.
19. Al-Zarea BK. Maximum bite force following unilateral fixed prosthetic treatment: a within-subject comparison to the dentate side. Med PrincPract. 2015;24(2):142-6.
20. Singhal MK, BudakotiVaibhav, Pratap Hemendra, Chourasiya Priyanka, Waghmare Anagha. A Comparative Assessment of Bite Pressure between Implant Prosthesis and Natural Teeth: An In vivo Study. International Journal of Scientific Study. July 2022: 10(4); 59-66.
21. Pizolato RA, Gavião MB, Berretin-Felix G, Sampaio AC, Junior AS. Maximal bite force in young adults with temporomandibular disorders and bruxism. Braz Oral Res 2007;21:278-83.
22. Proffit WR, Fields HW, Nixon WL. Occlusal forces in normal and long-face adults. J Dent Res 1983;62:566-70.
23. Bonjardim L, Gaviao M, Pereira L, et al. Bite force determination in adolescents with and without temporomandibular dysfunction. J Oral Rehabil. 2005;32:577–583.
24. Hagberg C. Assessments of bite force: a review. J CraniomandibDisord. 1987;1:162–169.
25. Koç D, Doğan A, Bek B. Effect of gender, facial dimensions, body mass index and type of functional occlusion on bite force. J Appl Oral Sci. 2011;19:274–279.
26. Bonakdarchian M, Askari N, Askari M. Effect of face form on maximal molar bite force with natural dentition. Arch Oral Biol. 2009 Mar;54(3):201-4.

27. Braun S, Hnat WP, Freudenthaler JW, et al. A study of maximum bite force during growth and development. Angle Orthod. 1996;66:261–264.
28. Al-Omiri MK, Sghaireen MG, Alhijawi MM, et al. Maximum bite force following unilateral implant-supported prosthetic treatment: within-subject comparison to opposite dentate side. J Oral Rehabil. 2014;41:624–629.