Relationship Between Dental Arch Dimensions and Bite Force: A Pilot Study

Hubungan antara Dimensi Lengkung Gigi dan Kekuatan Gigitan: Sebuah Studi Pendahuluan

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ABSTRACT

Bite force is a unique indicator of the functional state of the masticatory system. Many factors can influence the bite force, including age, craniofacial dimensions, periodontal support, etc. This study aims to assess the association between dental arch measurements and bite forces. A total of 41 individuals were recruited, consisting of dental students and patients seeking treatment at the dental hospital of the Faculty of Dentistry, Taibah University. The study began with the creation of alginate impressions and study models, which were then scanned for measurements using software analysis. Specific points marked on the models were identified, yielding eight linear measurements. The average and maximum bite forces were recorded for both the right and left sides. Data analysis was performed using the Mann-Whitney test, Pearson correlation test, and multiple regression analysis. The research showed no significant difference between the right and left sides' bite forces, and no significant relationship between the maximum anterior and posterior bite forces and mandibular arch dimensions. However, a weak correlation was found between the maximum bite force and mandibular intercanine width, left side arch length, and arch depth. Similarly, weak correlations were found between maximum bite force and maxillary first premolar arch width, second premolar arch width, and left-side arch length. In conclusion, no significant correlation was observed between the bite force and dental arch dimensions.

Keywords: Dental Arches, Arch Dimensions, Average bite force, Maximum bite

ABSTRAK

Kekuatan gigitan merupakan indikator unik dari kondisi fungsional sistem pengunyahan. Beberapa faktor yang dapat mempengaruhi kekuatan gigitan, termasuk usia, dimensi kraniofasial, dukungan periodontal, dan lainnya. Penelitian ini bertujuan untuk menilai hubungan antara ukuran lengkung gigi dan kekuatan gigitan. Sejumlah 41 orang direkrut, yang terdiri dari mahasiswa kedokteran gigi dan pasien yang mencari perawatan di rumah sakit gigi Fakultas Kedokteran Gigi, Universitas Taibah. Penelitian dimulai dengan pembuatan cetakan alginat dan model studi, yang kemudian dilakukan pengukuran menggunakan analisis perangkat lunak. Titik-titik tertentu yang ditandai pada model diidentifikasi, menghasilkan delapan pengukuran linier. Kekuatan gigitan rata-rata dan maksimum dicatat pada sisi kanan dan kiri. Analisis data dilakukan menggunakan uji Mann-Whitney, uji korelasi Pearson, dan analisis regresi berganda. Hasilnya menunjukkan tidak ada perbedaan signifikan antara kekuatan gigitan sisi kanan dan kiri, dan tidak ada hubungan signifikan antara kekuatan gigitan anterior dan posterior maksimum dan dimensi lengkung mandibula. Namun, korelasi lemah ditemukan antara kekuatan gigitan maksimum dan lebar interkaninus mandibula, panjang lengkung sisi kiri, dan kedalaman lengkung. Demikian pula, korelasi lemah ditemukan antara gaya gigitan maksimum dan lebar lengkung gigi premolar pertama rahang atas, lebar lengkung gigi premolar kedua, dan panjang lengkung sisi kiri. Sebagai kesimpulan, tidak ditemukan korelasi signifikan antara gaya gigitan dan dimensi lengkung gigi.

Kata kunci: Lengkung Gigi, Dimensi Lengkung, Rata-rata Kekuatan Ggigitan, Maksimum Gigitan

INTRODUCTION

Studying the configuration of the dental arches is of great importance and has a significant impact on orthodontic diagnosis, treatment planning, achieving optimal occlusion, and stability after orthodontic treatment. Moreover, people from different racial groups exhibit varied morphological traits, and these racial variations must be considered during diagnosis and orthodontic treatment planning rather than adopting a single standard for all cases.[1,2] On the other hand, mastication force, or bite force, is known as the communication between mandibular and maxillary bones and muscles.[3] Furthermore, biting force is a unique measure or indicator of the functional state of the masticatory system, particularly when evaluating jaw-closing muscle function.[4] There are a lot of elements that can influence the bite force, including age, craniofacial dimensions, dentition developmental stage, and periodontal support, in addition to the position of recording devices.[5-9] Bite force has a direct relationship with masticatory muscle activity, which affects mandibular development and remodeling.[10] Many fields in dentistry have inspected the maximum bite force to assess the efficiency of various dental treatments on the masticatory system. The prosthodontic and orthodontic fields are more concerned with that evaluation as well as the dimensions of dental arches such as arch form, arch width, and arch length; these parameters play a major role in diagnosis and formulating proper treatment in these two fields.[11, 12]

There is a lack of studies that relate the degree of bite force to the dimensions of the dental arches, and there is a deficiency in the literature on this subject and its relevance to facial deformities with diagnosis, prognosis, and treatment. Therefore, the purpose of this study was to evaluate the correlation between dental arch measurements and bite force.

RESEARCH METHODS

Ethical approval to conduct this study had been obtained from the Ethics Committee, College of Dentistry, University (N:TUCDREC/07022021). A total of forty-one male subjects (mean age 22.4± 1.6 years) were recruited from dental students and patients seeking treatment at the dental hospital, College of Dentistry, Taibah University. The inclusion criteria were: all subjects were eighteen years old or older, class I malocclusion, a normal overbite and overjet, and each maxillary and mandibular arch had fully erupted with no extracted or absent teeth. Individuals with a crossbite, missing teeth, cast restorations or cuspal coverage, previous or current orthodontic treatment, TMJ disorders, and periodontitis were excluded. The study protocol and procedures were explained to all subjects, and written informed consent was obtained. Alginate impressions were taken and poured using plaster stone. Then study models were trimmed according to the international standards. All study models were scanned using KaVo Artica Autoscan (Smart Optics Sensortchnik GmbH, Germany). All scanning and measurements were done by one technician. All scanned casts were imported into analysis software for measurements (3D Tool, version 13.30, 3D-Tool.com). The defined points on the scanned casts were identified, and then eight linear measurements were taken. (Figure 1)

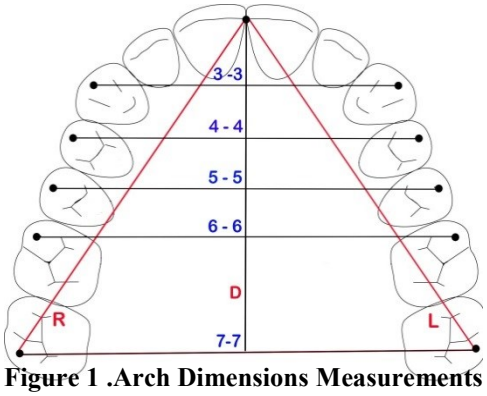

Figure 1 .Arch Dimensions Measurements

Caption: The figure shows intercanine width (3-3): the distance between the right and left canine's cusp tips. Interpremolar width (4-4): the distance between the right and left buccal cusps tips of the first premolar. Interpremolar width (5-5): the distance between the right and left buccal cusp tips of the second premolar. Intermolar width (6-6): the distance between the right and left mesiobuccal cusps tips of the first molar. Second intermolar width (7-7): the distance between the right and left destobuccal cusps tips of the second molar. Right arch length (R): the distance measured from the destobuccal cusp tip of the second molar on the right side to the midline. Left arch length (L): the distance measured from the destobuccal cusps of the second molar on the left side to the midline. Arch depth (D): the distance between the line connecting the second intermolar width to the midline.

Bite Force measurements

Participants were instructed to sit in an upright position without head support, with the Frankfort plane almost parallel to the floor. Each subject was told to bite as hard as they could on the gauge without moving their heads. The bite force was measured using a digital occlusal force gauge (GM10, Nagano Keiki, Japan). Bite force was recorded three times for fifteen seconds on each side, with a resting time of fifteen seconds between each bite. From these three records, the maximum and average bite forces were defined.

The data were subjected to the Shapiro–Wilks normality test, which was found to be not normally distributed. The Mann-Whitney test was used to compare the right and left sides. Pearson correlation and multiple regression tests were utilized to assess the degree of correlation between the dental arch dimensions and posterior and anterior bite forces. SPSS software was used to perform all statistical analyses (version 20, SPSS, Chicago, Illinois, USA). The p-value was set at < 0.05.

RESULTS

Table 1 displays the dimensions of the maxillary and mandibular dental arches.

Table 1: Dental Arch dimensions for the study group (n = 41)

	Upper Arch				Lower Arch			
	Mean	SD	Min	Max	Mean	SD	Min	Max
Intercanine width (3-3)	36.22	1.98	29.54	40.40	36.00	2.14	30.81	40.01
First Premolar Widths (4-4)	43.60	2.19	39.41	47.99	41.31	2.64	36.48	46.86
Second Premolar Widths (5-5)	48.87	2.37	44.56	53.54	47.03	2.69	41.69	52.45
First Molar Widths (6-6)	54.35	2.67	49.19	59.75	55.62	4.80	35.70	63.89
Second Molar Widths (7-7)	61.41	3.47	53.33	69.41	48.38	2.16	43.21	52.56
Arch Length (Right)	52.82	3.74	35.01	58.71	47.22	7.07	44.00	52.24
Arch Length (Left)	53.01	2.40	45.69	58.66	36.80	4.45	26.40	46.14
Arch Depth (mm)	40.48	4.37	29.53	47.03	36.80	4.45	26.40	46.14

SD: Standard deviation, Min: minimum, Max: maximum

Table 2: Average and maximum bite force for right side, left side, and both sides (N = 41)

Variable	Posterior Bite Force						P value	Anterior Bite Force	
	Both sides		Right Side		Left Side				
	Mean	SD	Mean	SD	Mean	SD		Mean	SD
Average Bite Force *	516.6	192.8	514.0	188.7	519.2	199.1	0.8	122.1	70.3
Maximum Bite Force *	560.8	194.3	560.5	193.9	561.1	197.0	0.9	139.2	75.4

*Newton

Table 2 shows the posterior bite forces for the total sample and a comparison between the right and left sides, in addition to the average and maximum anterior bite force. The average bite force was 516.6 ± 192.8 N, and the maximum bite force was found to be 560.8 ±194.3 N. The average anterior bite force was 122.1 ± 70.3, and the maximum anterior bite force was 139.2 ± 75.4. No significant difference between the bite forces on the right and left sides was found.

Correlations between posterior bite force and mandibular arch dimensions are presented in Table 3. No significant association was observed between the maximum anterior and posterior bite forces and mandibular arch dimensions. However, a weak relationship between the maximum bite force and intercanine width (R: 0.25), arch length on the left side (R: 0.25), as well as arch depth (R: 0.20) was found.

Table 3: Correlation between mandibular arch dimensions and posterior and anterior bite force

Variable	Maximum posterior bite force				Maximum anterior bite force			
	R	R^2	R^2 (ADJ)	*P* value	r	R^2	R^2 (ADJ)	p-value
Intercanine width (3-3)	0.25	0.06	0.04	0.10	0.04	0.00	-0.02	0.79
First Premolar Widths (4-4)	0.09	0.01	-0.02	0.55	0.10	0.01	-0.01	0.49
Second Premolar Widths (5-5)	0.03	0.00	-0.02	0.81	0.14	0.02	-0.01	0.37
First Molar Widths (6-6)	0.05	0.00	-0.02	0.70	0.05	0.00	-0.02	0.73
Second Molar Widths (7-7)	0.03	0.00	-0.02	0.84	0.22	0.05	0.03	0.15
Arch Length (Right)	0.09	0.01	-0.02	0.57	0.08	0.01	-0.02	0.64
Arch Length (Left)	0.25	0.06	0.03	0.10	0.17	0.03	0.00	0.28
Arch Depth (mm)	0.20	0.04	0.01	0.19	0.08	0.01	-0.02	0.63

R = Pearson correlation coefficient; R2 = Squared multiple correlation coefficient; R2 (ADJ) = Adjusted coefficient of determination

Table 4: Correlation between maxillary arch dimensions and maximum posterior and anterior bite forces

Variable	Maximum posterior bite force				Maximum anterior bite force			
	r	R^2	R^2 (ADJ)	p-value	R	R^2	R^2 (ADJ)	p-value
Intercanine width (3-3)	0.16	0.02	0.00	0.30	0.11	0.01	-0.01	0.51
First Premolar Widths (4-4)	0.20	0.04	0.02	0.19	0.08	0.01	-0.02	0.60
Second Premolar Widths (5-5)	0.21	0.04	0.02	0.19	0.01	0.00	-0.03	0.97
First Molar Widths (6-6)	0.11	0.01	-0.01	0.48	0.07	0.01	-0.02	0.65
Second Molar Widths (7-7)	0.09	0.01	-0.02	0.56	0.02	0.00	-0.03	0.89
Arch Length (Right)	0.23	0.06	0.03	0.13	0.02	0.00	-0.03	0.92
Arch Length (Left)	0.06	0.00	-0.02	0.72	0.09	0.01	-0.02	0.57
Arch Depth (mm)	0.09	0.01	-0.02	0.57	0.09	0.01	-0.02	0.57

R = Pearson correlation coefficient; R2 = Squared multiple correlation coefficient; R2 (ADJ) = Adjusted coefficient of determination

Concerning the correlation between maxillary arch dimensions and maximum posterior and anterior bite forces, no significant relationship was found among all the tested variables (Table 4). However, a weak correlation between maximum posterior bite force and first premolar width (R: 0.20), second premolar width (R: 0.21), and arch length on the right side (R: 0.23) was found.

DISCUSSION

Many devices for measuring bite force have been introduced in the literature.[13] This study has used a device that is simple, easy to use, comfortable, and has been proven to be effective.[14,15] It is common knowledge that men have a greater bite force than women[9,16], so to minimize the errors as much as possible and obtain reliable and accurate results, this study opted for an all-male sample and measured the bite force three times, and the mean from these three readings was then adopted.[15] Several reports have extensively explored the potential relationship between bite force and other dental procedures, such as the relationship between bite force with surgical orthodontics[17], prosthodontic procedures[18], temporomandibular disorders[19], and mandibular dimensions.[20] The association between bite force and the degree of occlusal contact has also been investigated.[21]

The number of occlusal contacts has been demonstrated to be a better predictor of biting force and muscle activity than the total number of teeth present.[22] One explanation for the relationship between occlusal contacts and bite

force is that "good" occlusal support – as the force is disseminated across numerous teeth- may result in higher jaw elevator muscles that can develop greater biting force. Therefore, in some situations orthodontic treatment may be required to enhance function and obtain proper occlusal tooth contact.

The relationship between bite force and orthodontic therapy has also been investigated.[23–25] Bite force and occlusal contacts have been reported to decrease temporarily during orthodontic treatment. [23] Therefore, it may be beneficial to constantly evaluate the occlusal contact and take it into account when planning orthodontic treatment.[3]

In this study, the average and maximum bite forces were 516.6 ± 192.8 and 560.8 ± 194.3 Newton, respectively, which is almost close to that reported for Jordanians [14] and less than those of other racial groups.[7,15] Algunaid et al.[20] investigated the association between mandibular measurements and biting force, comparing bite forces on the right and left sides. They failed to find an apparent difference between the two sides.[20] This is in line with our current findings, in which no difference was observed between the bite forces on the right and left sides. It also adheres to those observed by Palinkas et al.[16] ,Varga et al.,[15] and Araujo et al.[26], who failed to find any significant variations between the two sides, but differs from those reported by Bonakdarchian[27], and Alam and Alfawzan.[28]

Hayashi et al. [12] studied the alterations in the dental arch form and inclination of the first molars of two crowding groups and discovered a link between bite force and maxillary and mandibular dimensions. Al-Gunaid et al.[20] investigated the correlation between mandibular dimensions and the posterior bite force. They failed to find a remarkable association between the average and maximal posterior bite force and mandibular dimensions, except that the inclinations of the lower canine and lower first molar were significantly correlated with the bite force.[20] Our current finding is not in line with those reports, as no correlation was found between the magnitude of biting force and upper and lower arch width. As a suggestion for further research, it is necessary to control inclusion criteria such as dolicofacial, mesofacial and brachyfacial factors.

While this study should have used an even bigger sample size and recruited people from diverse racial origins with varied malocclusions, several clear distinctions found during this study may be useful in studying the bite force.

CONCLUSION

No apparent significant correlation exists between the bite force and maxillary and mandibular dental arch dimensions.

CONFLICT OF INTERESTS

The authors declare no conflict of interest.

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