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Ultrasound Findings of the Masseter Muscle in Patients with Bruxism

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Abstract
Background: Bruxism is a common parafunctional activity that causes destructive effects on the teeth, periodontal tissue, and temporomandibular joint, leading to hypertrophy and myositis of the masseter muscle. This study aimed to evaluate the sonography findings of masseter muscle among women with bruxism and compare them with those among healthy females.
Methods: The statistical population of this study consisted of 45 female volunteers, including 23 patients with bruxism and 22 healthy subjects, referring to the Prosthodontics Department. Masseter muscles were evaluated by sonography in each group bilaterally, at rest and maximum contraction positions, and in longitudinal and transverse planes in terms of thickness. It was also examined in terms of the pattern (type I, II, and III), echogenicity (hypo, intermediate, and hyper), internal structure (homogeneous and heterogeneous), and muscle fiber limits (well-defined, poorly-defined, and ill-defined).
Results: In the study of three variables of echogenicity, internal structure, and boundaries of muscle in patients with bruxism, less echogenicity ($P \leq 0.011$), heterogeneous structure ($P \leq 0.003$), and indeterminate boundaries ($P = 0.000$) were predominant, and there was a significant relationship between the two groups. Moreover, the examination of the difference in muscle thickness between the two groups showed that only the thickness of the left masseter muscle in the longitudinal plane and at rest position was significant between the healthy and bruxism groups ($P = 0.040$).
Conclusion: There were marked sonographic changes in the masseter muscle in women with bruxism, indicating that the bruxism may affect the masseter muscle.
Keywords: Masseter muscle, Ultrasonography, Bruxism

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Introduction

Bruxism is a parafunctional activity of the masticatory muscles during the day or night, characterized by aimless tooth clenching. The symptoms of this disorder include masticatory muscle hypertrophy, myositis, morning stiffness, tooth sensitivity, and broken dental restorations (1,2). The parafunctional activity of the masticatory muscles is observed in 60% and 80% of healthy individuals and patients with bruxism, respectively. The masseter, temporalis, and internal pterygoid muscles are continuously stimulated during bruxism (3).

Recently, masseter muscle thickness has been considered a marker for the function of this muscle. Unilateral or bilateral master hypertrophy is observed in patients with long-term bruxism, which leads to facial asymmetry, discomfort, and adverse effects in numerous patients (1,2,4).

The masseter muscle can be evaluated using computed tomography (CT) and magnetic resonance imaging techniques. However, since ultrasound is a safe, repeatable, fast, inexpensive, and non-invasive method (1), it can be highly beneficial in evaluating the quality and quantity of this muscle when it is accompanied by complete and accurate information about the anatomy of the study area (5,6). The masseter muscle is a superficial muscle, easily identifiable on ultrasound examination, and known as a homogeneous structure near the mandibular echogenic band (1,7).

To the best of our knowledge, few studies have investigated the anatomical sonographic appearance and normal variations of the masseter muscle in healthy individuals and its changes in quality (i.e., internal structure, echogenicity, pattern, and boundaries) and quantity (i.e., thickness) in patients with parafunction. Therefore, this study aimed to compare the masseter muscle via sonography in patients with parafunctional habits of the bruxing events with healthy individuals.

Methods

This cross-sectional study was conducted in the Department of Oral and Maxillofacial Radiology, School of Dentistry, Mashhad University of Medical Sciences, Mashhad, Iran, from November 2017 to March 2019. The research objectives and procedures were explained to all participants, and informed consent was obtained from the subjects. The samples (n = 45) consisted of healthy females (n = 22) and women with bruxism (n = 23) referring to the Prosthodontics Department of the School of Dentistry. All subjects were in the age range of 20-52 years, and the mean age was not significantly different between the two groups.

In this study, patients with bruxism were classified into three groups in terms of the duration of the disorder, namely less than one year, 1-2 years, and more than three years. It was revealed that 52% of the patients were suffering from bruxism for less than a year (Table 1).

Inclusion criteria

The bruxism group consisted of female patients whose bruxism was confirmed by a prosthetist and were in the research diagnostic criteria for the temporomandibular disorders group. The control group included female volunteers with normal facial muscles, Class I occlusion, and no muscle hypertrophy.

Exclusion criteria

The exclusion criteria were having a history of previous facial muscle disease (e.g., Bell’s palsy), a history of radiotherapy in the head and neck, consumption of medications affecting the function and structure of the facial muscles, a history of functional orthodontic treatment or surgery, specific eating habits (e.g., eating solid foods), history of Botox injections in facial muscles, and high body mass index (BMI) and reaching menopause.

Before the onset of each ultrasound examination, a dentist performed a clinical examination, including concurrent dental abrasions, cheek biting, crenated tongue, broken restorations, and masseter muscle pain.

Technique

An oral and maxillofacial radiologist performed sonography examinations with approximately 5 years of experience in the field of ultrasound through grayscale sonography (CTS-7700C, China) and a multi-frequency linear probe (5-10 MHz). All scans were saved. To conduct sonography, the patients were placed in the supine position so that the mandible was relaxed and the masseter muscle had no function. To obtain a transverse scan of the masseter muscle, the probe was placed with minimal pressure perpendicular to the muscle’s anterior edge and the ramus mandible’s surface at the opposite side of the occlusal plane approximately in the middle part of the muscle. The reason for placing the probe in this position lies in the fact that according to the results of studies, the middle part of the muscle has the highest reliability in measuring thickness, on the other hand, the thickest muscle is located in the middle dimension of the mediolateral Ramus mandible (5).

To obtain a longitudinal scan, the probe was placed vertically with minimal pressure parallel to the muscle’s anterior edge and the ramus mandible’s surface in the middle of the muscle. The resting position of the masseter muscle is when there is a distance of about 8-9 mm (3) between the teeth, and the muscle is at its minimum electromyographic activity. However, the maximum contraction of the masseter occurs when with the contraction of this muscle, the jaws are closed, and the teeth are in an occlusive position with the maximum pressure on each other. Eight scans were obtained from each patient’s masseter muscles, including two transverse scans at rest and the maximum contraction positions and two longitudinal scans at rest and the maximum contraction on each side. Generally, 90 masseter muscles were examined, and 360 ultrasound scans were obtained.

Study variables included masseter muscle thickness, echogenicity (hypo echo, intermediate echo, and hyper echo), internal structure (homogeneous and heterogeneous), muscle fiber boundaries (well-defined, poorly defined, and ill-defined), and muscle type (I, II, III). Muscle thickness was measured from the lower edge of the subcutaneous fat to the ramus, directly at the time of scanning, at rest and the maximum contraction, and in longitudinal and transverse planes.

The internal pattern of the masseter muscle in ultrasound was divided into three groups based on the echogenic bands’ visibility and the bands’ width and echogenicity. Ultrasound images of each subject in both groups were placed in one of the following categories in real-time ultrasound based on the results of a study conducted by Imanimoghaddam et al (5). These categories include:

- Group I: In this case, the pattern of the masseter muscle is normal, in which fine and thick hyperechoic bands are clearly visible (Figure 1).
- Group II: In this category, a decrease in the number of fine and thick bands, an increase in the thickness of the remaining bands, and a decrease in the echogenicity of the bands are evident (Figure 2).

Table 1. Frequency distribution of involvement duration in people with bruxism inclusion criteria

Group	Less than1 year		1-3 years		>3 years	
	Number	Percent	Percent	Percent	Number	Percent
Bruxism	12	52	6	26	5	21

- Group III: This type is divided into two subgroups, including type IIIa with a sharp decrease in the number of bands and type IIIb with the loss of bands (Figure 3).

Groups II and III are determined as abnormal muscle states.

Normal masseter muscle has a homogeneous internal structure, clear boundaries, and high echogenicity. Based on the results of studies, inflamed masseter muscle is observed as a decrease in the echogenicity of the echogenic bands and the loss of homogeneous structure. These bands are reduced or destroyed by inflammation; therefore, this finding is an essential structural indicator of masseter muscle infection and inflammation (8). The two groups in this study were also evaluated in terms of these three variables.

Statistical analysis

To evaluate the relationship between qualitative variables, the χ^2 test was used. Independent t-test and paired sample test were employed to compare the mean of quantitative variables in different people and the variable in each group between the right and left sides, respectively. In all tests, a *P* value of 0.05 was considered significant. Data description and analysis were performed using PASW Statistics for Windows (version 18; SPSS Inc., Chicago, IL, USA).

Results

The samples of this study (n = 45) included 20-52-year-old females in two groups of patients with bruxism (n = 23) and control (n = 22) referring to the center to obtain ultrasound images. None of the subjects were excluded from the study. The mean age scores of the cases

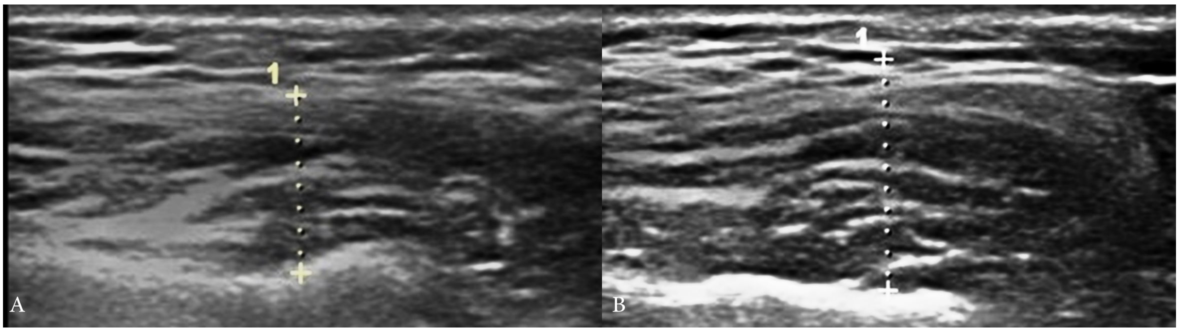

Figure 1. Normal ultrasound view of the masseter muscle (internal pattern of group I) in a healthy 30-year-old woman. Fine and thick bands of hyperecho are well visible. A: Thickness of the muscle at rest: 11 mm, B: Thickness of the muscle during contraction: 15 mm

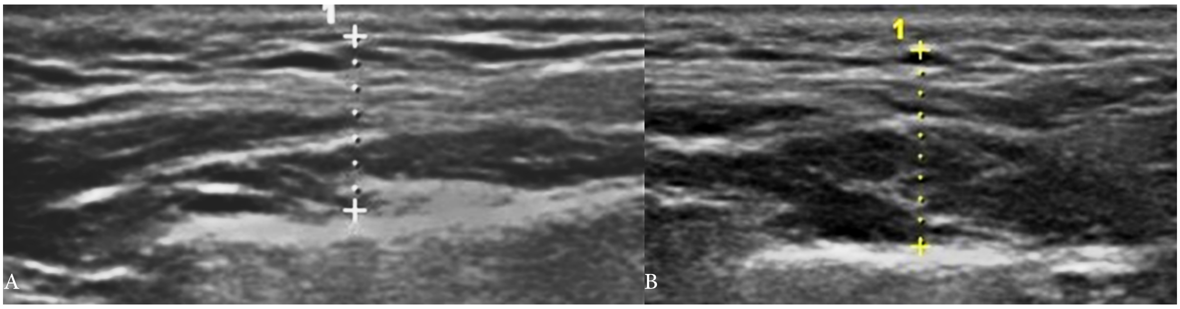

Figure 2. Ultrasound view of group II (abnormal posture) in a 27-year-old woman. Note the reduction of fine bands and the residual band echoes. A: Muscle sonogram at rest, muscle thickness: 11.03 mm, B: Muscle sonogram in contraction, muscle thickness: 13.08 mm

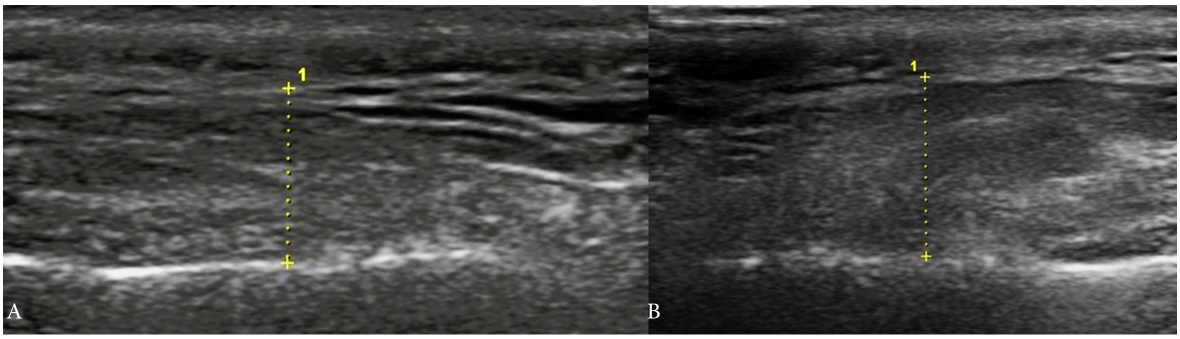

Figure 3. Ultrasound view of group IIIa (abnormal condition) in a 20-year-old woman. Notice the sharp decrease in muscle bands. A: Muscle sonogram at rest, muscle thickness: 9.9 mm, B: Muscle sonogram at contraction, muscle thickness: 12.01 mm

were 33.09 ± 7.36 and 28 ± 6.56 in the bruxism and control groups, respectively.

The examination of the echogenicity of the masseter muscle showed a significant relationship between the presence of bruxism and the echogenicity of the right and left masseter muscles in both transverse and longitudinal planes ($P \leq 0.011$) as the echogenicity of the masseter muscle in people with bruxism progressed to become hypoechoic (Tables 2 and 3).

There was also a significant relationship between the presence of bruxism and the internal structure of the right and left masseter muscles in longitudinal and transverse planes ($P \leq 0.003$). Accordingly, the highest frequencies were reported for homogeneity and heterogeneity in the healthy and bruxism groups, respectively (Tables 4 and 5).

It was also revealed that the highest frequencies of muscle boundaries belonged to the ill-defined and well-defined boundaries among the patients with bruxism and healthy individuals, respectively ($P = 0.000$) (Table 6).

In the study of masseter muscle patterns, the highest frequencies were related to type I and type II patterns in the healthy and bruxism groups; nevertheless, no significant relationship was observed in this regard. According to the results of our study, the examination of the difference in muscle thickness between the two groups showed that only the thickness of the left masseter muscle in the longitudinal plane and at rest was significant between the healthy and bruxism groups ($P = 0.040$).

Discussion

Today, the findings of studies have indicated that ultrasonography can reveal the morphology of the masseter muscle and other superficial muscles as an alternative method (8,9). In addition, sonography is an accurate and reliable method of measuring the thickness of the masseter muscle and shows the internal structures of the muscles much more clearly than CT (7,10,11). Therefore, this study was performed to find sufficient information about masseter muscle sonography, determine its sonographic changes in the bruxism group, and compare them with those in the healthy group.

In the present study, no statistically significant difference was observed between the thickness of the right and left masseter muscles at rest and the maximum contraction in the two groups of healthy and bruxism. The only significant difference was found in the thickness of the left master muscle in the longitudinal plane and at rest between the two groups ($P = 0.040$), which was in line with those of studies conducted by Imanimoghaddam et al (5), Georgiakaki (12) and Raadsheer et al (13). However, the findings of the present research study were inconsistent with those of a study conducted by Najm showing that the thickness of the left and right masseter muscle at rest and contraction positions was different between individuals in both healthy and bruxism groups (1). The reason for this discrepancy can be the shorter duration of the disorder (52% less than one year) among the patients in our study and, consequently, the lower impact of this inflammation on the masticatory muscles.

According to the results of a study by Raghunandan Iyengar et al, the degree of change depends on both the bruxism duration and the force exerted during bruxism (14). The other factors influencing the degree of changes include various individual differences affecting the thickness of the masseter muscle, such as the dominant side that the patient uses to chew and the racial, genetic, and environmental variations of different patients (e.g., morphology, face height, BMI, edentulousness, age, gender, and scan time).

Based on a study performed by Satiroğlu, individuals with shorter face heights had thicker masseter muscles (15). In another study, Yamaguchi et al reported that the thickness of the masseter muscle was associated with age in both genders and tooth loss in women (16). Kiliaridis et al evaluated the sonography of sixty 7-18-year-old patients

Table 2. Echogenicity of right and left masseter muscles in longitudinal and transverse planes in two groups

Plane and side	χ^2	*P* value
Right transverse plane	8.986	0.011
Left transverse plane	12.777	0.002
Right longitudinal plane	16.786	<0.001*
Left longitudinal plane	20.277	<0.001*

*Significant.

Table 4. Evaluation of the relationship between the internal structure (homogeneity and heterogeneity) of right and left masseter muscles in longitudinal and transverse planes in two groups

Plane and side	χ^2	*P* value
Right transverse plane	8.538	0.003
Left transverse plane	11.745	0.001
Right longitudinal plane	9.911	0.002
Left longitudinal plane	16.243	<0.001*

*Significant.

Table 3. Echogenicity frequency distribution of right and left masseter muscles in longitudinal and transverse planes in the two groups

Group	Right transverse plane			Left transverse plane			Right longitudinal plane			Left longitudinal plan		
	Hypo	Intermediate	Hyper	Hypo	Intermediate	Hyper	Hypo	Intermediate	Hyper	Hypo	Intermediate	Hyper
Control	2 (9.1)	5 (22.7)	15 (68.2)	3 (13.6)	7 (31.8)	12 (54.5)	2 (9.1)	4 (18.2)	16 (72.7)	2 (9.1)	4 (18.2)	16 (72.7)
Bruxism	9 (22.7)	8 (34.8)	6 (26.1)	12 (52.2)	9 (39.1)	2 (8.7)	10 (43.5)	10 (43.5)	3 (13.0)	13 (56.5)	8 (34.8)	2 (8.7)

Note: Data are expressed as number (percent).

Table 5. Frequency distribution of internal structure (homogeneity and heterogeneity) of right and left masseter muscles in longitudinal and transverse planes in two groups

Group	Right transverse plane		Left transverse plane		Right longitudinal plane		Left longitudinal plane	
	Hypo	Hyper	Hypo	Hyper	Hypo	Hyper	Hypo	Hyper
Control	18 (81.8)	4 (18.2)	16 (72.7)	6 (27.3)	17 (77.3)	5 (22.7)	18 (81.8)	4 (18.2)
Bruxism	9 (39.1)	14 (60.09)	5 (21.7)	18 (78.3)	7 (30.04)	16 (69.6)	5 (21.7)	18 (78.3)

Note: Data are expressed as number (percent).

Table 6. Comparison of the highest frequency distribution of right and left masseter muscle fiber types in transverse and longitudinal planes in the two groups

Group	Right transverse plan			Left transverse plan			Right longitudinal plan			Left longitudinal plan		
	Well defined	Poorly defined	Ill-defined	Well defined	Poorly defined	Ill-defined	Well defined	Poorly defined	Ill-defined	Well defined	Poorly defined	Ill-defined
Control	11 (50.0)	10 (45.5)	1 (4.5)	16 (72.7)	5 (22.7)	1 (4.5)	15 (68.2)	5 (22.7)	2 (9.1)	18 (81.8)	3 (13.6)	1 (4.5)
Bruxism	0 (0)	12 (52.2)	11 (47.8)	1 (4.3)	11 (47.8)	11 (47.8)	0 (0)	10 (43.5)	13 (56.5)	2 (8.7)	6 (26.1)	15 (65.2)

Note: Data are expressed as number (percent).

at rest and under contraction conditions. Accordingly, the muscle thickness was much less than that in the present study (17). The reason for this matter lies in the fact that there is probably a positive correlation between muscle thickness and age (18).

Park et al concluded that masseter muscle thickness was directly related to facial morphology in both genders and age in men (19). Yamaguchi et al (16) and Chang et al (18) concluded that masseter muscle thickness was more affected by age in males than in females. However, masseter muscle thickness showed no relationship with age and gender in a study performed by Odkhuu et al, which was probably due to the small sample size (n = 27) (20). It has been revealed that the thickness of the masseter muscle can also be affected by BMI (18,21). The case in the present study lacked a very high BMI.

Based on the results of a study conducted by Satiroğlu et al, the mean thickness of the masseter muscle at rest and contraction positions was higher in the Turkish population than in the subjects of our study. This discrepancy can be attributed to both the difference in races and the study of both male and female groups since higher muscle thickness has been demonstrated in men (15). Barotsis et al measured the masseter muscle thickness by ultrasound in the longitudinal and transverse planes among healthy volunteers. They concluded that the thickness of the muscles, including the masseter, varies depending on the time and orientation of the scan and the body position during scanning (22).

These variations of masseter muscle thickness among different populations can be due to racial differences, and consequently, lead to diverse orientations, sizes, and different compositions of muscle fibers. Therefore, the effects of genetic and environmental variability on muscle development cannot be ignored. The location of evaluating the masseter muscle is also essential during the ultrasound since the thickness of the muscle varies from point to point. Both Bertram and Emshoff reported that ultrasonography was a repeatable method of measuring muscle cross-sectional area in the middle and lower levels (23,24). In our study, the measurement was performed at the middle level.

In the present study, a significant relationship was observed in the internal structure (i.e., homogeneity and heterogeneity) between the healthy and bruxism groups. Regarding this, in individuals with bruxism, the number of muscle-decreasing fibers and the homogeneity of the internal structure were reduced. Based on the results of the study conducted by Najm, there was a significant difference in the type of internal pattern of masseter muscle between the two groups of bruxism and control (1).

In the study of masseter muscle echogenicity, a significant relationship was revealed between the presence of bruxism and muscle echogenicity as the echogenicity of the masseter muscle in people with bruxism progressed to become hypoechoic, compared to those in the healthy group. According to the findings of a study carried out by Ariji et al, an essential structural indicator of masseteric infection and inflammation can be the reduction of echo intensity and the absence of partial or complete echogenic bands related to the internal fascia or tendons, which are commonly seen on ultrasound images of healthy muscles (11).

Regarding the frequency of the limit types, the highest frequency in the healthy group was related to the well-defined limits, followed by poorly-defined ones. However, in the bruxism group, the highest frequencies were related to ill-defined and poorly-defined limits in descending order. A significant difference was revealed between the two groups regarding this, meaning that a well-defined limit was observed in only 2 out of 23 patients with bruxism. This feature, which has not been investigated in previous studies, is similar to echogenicity, and internal structure indicates a deterioration in muscle quality due to bruxism and muscle inflammation.

In the study performed by Najm, it was reported that the highest frequency of muscle patterns in the bruxism group was related to the type II pattern (45%) (1). Likewise, based on the findings of the study conducted by Imani Moghaddam et al. in the field of myofascial pain, the type II pattern was predominant in the masseter muscle (5). In our study, the highest frequencies of muscle pattern type were related to the group I and group II patterns among the healthy individuals and the bruxism group, respectively. Nonetheless, no significant relationship was observed regarding this, which could be attributed to the fact that the subjects were in the early stages of the disease (52% under one year), and their muscle inflammation had not yet reached the point of being able to change muscle patterns. It was revealed that inflammation had been able to change echogenicity, boundaries, and internal structure; however, it was not strong enough to change the pattern. To evaluate this hypothesis, it is required to perform further studies with larger sample sizes and examine the relationship between the duration of inflammatory involvement of muscles and their pattern change. Larger sample sizes are essential for increasing the analysis's power and enhancing the findings' reliability. This limitation restricts the generalizability of the results to broader populations.

Conclusion

This study revealed significant ultrasound changes in the masseter muscle of women with bruxism, specifically in echogenicity, internal structure, and the delineation of muscle fibers. These findings suggest that bruxism can adversely affect the masseter muscle. The observed changes underscore the potential of ultrasound as an important diagnostic tool for assessing bruxism-related muscle alterations.

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Authors' Contribution

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Methodology: Mahrokh Imanimoghaddam, Parvaneh Armanpour.
Project administration: Parvaneh Armanpour.
Resources: Ali Bagherpour.
Software: Ali Bagherpour.
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Validation: Mahrokh Imanimoghaddam, Azam Sadat Madani.
Visualization: Faeze Zomorrodian.
Writing–original draft: Mahrokh Imanimoghaddam, Azam Sadat Madani, Parvaneh Armanpour, Ali Bagherpour, Faeze Zomorrodian.

Competing Interests

The authors declare that they do not have any conflict of interest.

Ethical Approval

This is an observational study, and only the samples that were radiographed at the discretion of the orthodontist were used, and no patient was exposed due to this study. This study was approved by the Ethics Committee of Mashhad University of Medical Sciences (Ethical code: IR.mums.sd.REC.1394.300).

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References

1. Najm AA. Sonographic evaluation of masseter muscle thickness in bruxist and non-bruxist subjects. J Baghdad Coll Dent. 2014;26(3):49-52. doi: 10.12816/0015224.
2. Aslan EM, Artaş A. Ultrasonographic assessment of masseter and anterior temporal muscle thickness and internal structure in young adult patients with bruxism. J Clin Ultrasound. 2025;53(2):286-93. doi: 10.1002/jcu.23866.
3. Okeson JP. Management of Temporomandibular Disorders and Occlusion-E-book. Elsevier Health Sciences; 2019.
4. Lee YH, Chun YH, Bae H, Lee JW, Kim HJ. Comparison of ultrasonography-based masticatory muscle thickness between temporomandibular disorders bruxers and temporomandibular disorders non-bruxers. Sci Rep. 2024;14(1):6923. doi: 10.1038/s41598-024-57696-6.
5. Imanimoghaddam M, Davachi B, Madani AS, Nemati S. Ultrasonographic findings of masseter muscle in females with temporomandibular disorders. J Craniofac Surg. 2013;24(2):e108-12. doi: 10.1097/SCS.0b013e3182646af0.
6. Kilinc HE, Onan D, Ulger O. Investigation of masticatory muscle thickness and mechanosensitivity of cervical and masticatory muscles in myofascial temporomandibular disorder patients with bruxism: a cross-sectional study. Musculoskelet Sci Pract. 2024;70:102919. doi: 10.1016/j.msksp.2024.102919.
7. De Nordenflycht D, Figueroa K, Muñoz J, De la Torre Canales G. Ultrasonographic characteristics of myogenous temporomandibular disorders: a scoping review. J Oral Rehabil. 2024;51(10):2209-19. doi: 10.1111/joor.13801.
8. Ariji Y, Sakuma S, Izumi M, Sasaki J, Kurita K, Ogi N, et al. Ultrasonographic features of the masseter muscle in female patients with temporomandibular disorder associated with myofascial pain. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2004;98(3):337-41. doi: 10.1016/j.tripleo.2004.06.068.
9. Pires PF, Rodrigues-Bigaton D. Evaluation of integral electromyographic values and median power frequency values in women with myogenous temporomandibular disorder and asymptomatic controls. J Bodyw Mov Ther. 2018;22(3):720-6. doi: 10.1016/j.jbmt.2017.09.001.
10. Dupont AC, Sauerbrei EE, Fenton PV, Shragge PC, Loeb GE, Richmond FJ. Real-time sonography to estimate muscle thickness: comparison with MRI and CT. J Clin Ultrasound. 2001;29(4):230-6. doi: 10.1002/jcu.1025.
11. Ariji E, Ariji Y, Yoshiura K, Kimura S, Horinouchi Y, Kanda S. Ultrasonographic evaluation of inflammatory changes in the masseter muscle. Oral Surg Oral Med Oral Pathol. 1994;78(6):797-801. doi: 10.1016/0030-4220(94)90098-1.
12. Georgiakaki I, Tortopidis D, Garefis P, Kiliaridis S. Ultrasonographic thickness and electromyographic activity of masseter muscle of human females. J Oral Rehabil. 2007;34(2):121-8. doi: 10.1111/j.1365-2842.2006.01677.x.
13. Raadsheer MC, Van Eijden TM, Van Spronsen PH, Van Ginkel FC, Kiliaridis S, Prahl-Andersen B. A comparison of human

masseter muscle thickness measured by ultrasonography and magnetic resonance imaging. Arch Oral Biol. 1994;39(12):1079-84. doi: 10.1016/0003-9969(94)90061-2.

14. Raghunandan Iyengar A, Patil S, Guddannanavar Karibasappa G, Beloor Vasudev S, Kumar Joshi R. Evaluation of internal echogenic pattern of masseter in subjects with myofascial pain/ myositis, oral submucous fibrosis, chewers, bruxers and healthy individuals- a preliminary ultrasonographic study. J Dent (Shiraz). 2016;17(4):361-6.
15. Satiroğlu F, Arun T, Işik F. Comparative data on facial morphology and muscle thickness using ultrasonography. Eur J Orthod. 2005;27(6):562-7. doi: 10.1093/ejo/cji052.
16. Yamaguchi K, Hara K, Nakagawa K, Namiki C, Ariya C, Yoshimi K, et al. Association of aging and tooth loss with masseter muscle characteristics: an ultrasonographic study. Clin Oral Investig. 2020;24(11):3881-8. doi: 10.1007/s00784-020-03255-y.
17. Kiliaridis S, Georgiakaki I, Katsaros C. Masseter muscle thickness and maxillary dental arch width. Eur J Orthod. 2003;25(3):259-63. doi: 10.1093/ejo/25.3.259.
18. Chang PH, Chen YJ, Chang KV, Wu WT, Özçakar L. Ultrasound measurements of superficial and deep masticatory muscles in various postures: reliability and influencers. Sci Rep. 2020;10(1):14357. doi: 10.1038/s41598-020-71378-z.
19. Park KM, Choi E, Kwak EJ, Kim S, Park W, Jeong JS, et al. The relationship between masseter muscle thickness measured by ultrasonography and facial profile in young Korean adults. Imaging Sci Dent. 2018;48(3):213-21. doi: 10.5624/isd.2018.48.3.213.
20. Odkhuu M, Kim J, Kim SJ. An ultrasonographic evaluation of masseter muscle thickness in patients having parafunctional habit. J Korean Dent Sci. 2020;13(2):59-66. doi: 10.5856/jkds.2020.13.2.59.
21. Yamaguchi K, Tohara H, Hara K, Nakane A, Yoshimi K, Nakagawa K, et al. Factors associated with masseter muscle quality assessed from ultrasonography in community-dwelling elderly individuals: a cross-sectional study. Arch Gerontol Geriatr. 2019;82:128-32. doi: 10.1016/j.archger.2019.02.003.
22. Barotsis N, Tsiganos P, Kokkalis Z, Panayiotakis G, Panagiotopoulos E. Reliability of muscle thickness measurements in ultrasonography. Int J Rehabil Res. 2020;43(2):123-8. doi: 10.1097/mrr.0000000000000390.
23. Bertram S, Bodner G, Rudisch A, Brandlmaier I, Emshoff R. Effect of scanning level and muscle condition on ultrasonographic cross-sectional measurements of the anterior masseter muscle. J Oral Rehabil. 2003;30(4):430-5. doi: 10.1046/j.1365-2842.2003.01052.x.
24. Emshoff R, Bertram S, Brandlmaier I, Scheiderbauer G, Rudisch A, Bodner G. Ultrasonographic assessment of local cross-sectional dimensions of masseter muscle sites: a reproducible technique? J Oral Rehabil. 2002;29(11):1059-62. doi: 10.1046/j.1365-2842.2002.00939.x.