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RESEARCH

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Evaluation of masseter muscle thickness of mouth breathing patients using ultrasonography

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Abstract

Background Chronic mouth breathing negatively affects the growth of the craniofacial complex and creates problems on the dental structures and adjacent skeletal muscle structures. In this study, it was aimed to investigate the possible effects of this situation on the muscles in the chewing system by evaluating the masseter muscle thickness in mouth-breathing individuals by ultrasonography.

Materials and methods A total of 50 patients (26 males and 24 females) between the ages of 18–65 years were included in the study and constituted the mouth breathing group, while a total of 50 patients (24 males and 26 females) constituted the control group. The masseter muscles of the patients were monitored both at rest and during contraction, separately on the right and left sides for both groups, and thickness measurements were made by ultrasonography imaging.

Results According to the data obtained, the masseter muscle thickness values of the mouth breathing male patient group were found to be significantly lower than the control male group according to the variables of side and contraction status ($p < 0.05$), while no significant value was observed in the comparison of the female patient group and the control group ($p > 0.05$). While no difference was observed in the evaluation of the patient and control groups according to age factors ($p > 0.05$), the muscle thicknesses of male patients were significantly higher than those of female patients on both sides and in both positions in the gender variable ($p < 0.05$).

Conclusion It can be stated that mouth breathing causes a negative effect on masticatory functions by creating an obstacle to normal physiology in the masticatory system and reduces the activation of the masseter muscle, which is one of the main elements of masticatory function.

Keywords Mouth breathing, Ultrasonography, Masticatory muscles, Masseter muscle

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Introduction

Nasal breathing is considered a very important factor in the normal physiologic development of orofacial structures with its effects on muscles and bones and is a necessary function for a healthy anatomy. When the physiology of nasal breathing deviates from its natural form for various reasons, a mouth breathing pattern emerges, which is a pathologic version of respiration [1, 2].

Mouth breathing is a condition with a multifactorial etiology and is considered a pathologic version of the normal breathing pattern in which inhaled air enters partially or completely through the oral cavity. Some of the etiologies of mouth breathing include deviated septum, nasal polyps, nasal concha hypertrophy, allergic rhinitis and pathologic hypertrophy of adenoids and tonsils [3, 4]. When mouth breathing becomes continuous, it predisposes to craniofacial changes. Lower than normal positioning of the mandible, anterior and inferior positioning of the tongue, elevated positioning of the head and low posture of the hyoid bone are possible consequences. Mouth breathing, deformities of the jaws, malocclusions of the teeth, abnormalities of the alveolar process, and skeletal malformations of the long thin face, such as the adenoid facial form, are also among the predisposing factors [5, 6]. The muscles and lips are thought to be responsible for the skeletal and dental changes that occur in mouth breathers. The unbalanced muscle pressures that occur in people who breathe through the mouth all the time are the precursors of these abnormal changes. Due to the lips remaining open, the tongue is positioned down and forward, forcing the mandible to be positioned down. This leads to inadequate function of the lips and muscles, forward movement of the anterior teeth, narrowing of the maxillary dental arch and poor muscle tone [7, 8].

The four main muscle groups that provide masticatory function are involved in the movements of the mandible (the masseter, temporal, lateral pterygoid and medial pterygoid muscles). The masseter, temporal, and medial pterygoid muscles are mainly responsible for the bite force and the closing movement of the mandible, while the lateral pterygoid and infrahyoid muscles are responsible for the opening movement of the mandible [9].

The masseter muscle is a rectangular shaped thick muscle that is very effective in mastication and consists of two parts as pars profundus and pars superficialis. It starts from the zygomatic arch and ends lateral to the lower edge of the mandible. The main function of the masseter muscle is to apply masticatory force by elongating the mandible and closing the jaw by contraction of its fibers [10]. The masseter muscle, which is among the masticatory muscles, is important enough to be considered as the basic building block of the masticatory system and has been the subject of many scientific studies. Being able to visualize the function of the masseter muscle and having information about its morphology can provide an advantage in dental clinical applications [11]. In imaging soft tissues such as masticatory muscles, ultrasonographic imaging provides advantageous conditions in terms of eliminating ionizing radiation exposure, providing reproducibility with real-time images and working more economically and faster [12, 13].

Ultrasonography is often the most commonly used imaging technique for the evaluation of masticatory muscles and determination of muscle size, but this is limited to superficial masticatory muscles, i.e. the masseter and temporal muscle can be observed, while lateral and medial pterygoid muscle evaluations do not give accurate results. It has proven to be effective in examining the structure and thickness of the masseter and its application is considered to be practical. With ultrasonographic imaging, volumetric values such as thickness, length, cross-sectional area of the muscles can be determined [14, 15]. Since the masseter muscle is superficially located with its homogeneous structure, its evaluation can be considered fast and reliable. Masseter muscle thickness values have been the subject of many studies because they are related to the masticatory system and craniofacial functional mechanisms. Muscle thickness and facial morphology are thought to depend on factors such as bite force and occlusal morphology [11, 15].

Ultrasonography (USG) is a diagnostic method that allows the examination of soft tissues and parenchymal internal organs using ultra sound waves. Free of X-rays and ionizing radiation risks, these sound waves are considered safe, including for pregnant women and infants [16]. Ultrasound imaging in dentistry can be used to examine major salivary glands, masticatory muscles, cervical lymph nodes, and superficial soft tissues of the face and neck.

Masseter muscle thickness values have been presented in many studies because they are related to the masticatory system and craniofacial functional mechanisms. Muscle thickness and facial morphology are thought to depend on factors such as bite force and occlusal morphology. Many studies have reported that muscle anatomy is related to anthropometric variables and physiognomy [14, 17, 18]. Muscles and lips may be thought to be responsible for the skeletal and dental changes that occur in mouth breathers. According to this information, the aim of this study was to investigate the possible effects of mouth breathing on the muscles in the masticatory system.

Materials and methods

Population

The groups were selected among the patients who came to Alanya Alaaddin Keykubat University Oral and Maxillofacial Radiology clinic for examination and agreed to participate in our study. A total of 50 patients, 26 males and 24 females, aged between 18 and 65 years, were included in the study and constituted the mouth breathing group, while a total of 50 patients, 24 males and 26 females, constituted control group with the nasal breathing. An experienced oral and maxillofacial radiologist (M.N.K.) performed USG measurements. Same observer made examination of temporomandibular joint to diagnose possible temporomandibular dysfunction.

Inclusion criteria for the mouth breathing group

- The patients were diagnosed as mouth breather by medical doctors previously,
- Between the ages of 18–65, without any systemic disease and not taking medication regularly,
- No teeth clenching/grinding habits and temporomandibular joint problems,
- No history of bruxism in the past,
- No one-sided chewing,
- No history of any trauma in the maxillofacial region and no history of any surgical procedure in this region,
- There is no infection that may involve the masseter muscle,
- No missing teeth, especially in the posterior region (except 3rd molars),
- Individuals who breathe by mouth due to nasal congestion, allergic conditions, deviated septum and who have problems such as snoring and apnea during sleep were included.

Inclusion criteria for the control group (non-mouth breather subjects)

- Between the ages of 18–65, without any systemic disease and not taking medication regularly,
- No teeth clenching/grinding habits and temporomandibular joint problems,
- No history of bruxism in the past,
- No one-sided chewing,
- No history of any trauma in the maxillofacial region and no history of any surgical procedure in this region,
- There is no infection that may involve the masseter muscle,
- No missing teeth, especially in the posterior region (except 3rd molars),
- No history of asthma, chronic obstructive pulmonary disease.
- Individuals who did not have nasal pathology and had not undergone a surgical procedure involving the nose in the past, who did not have an allergic condition, and who could easily perform nasal breathing were included.

Ethical considerations

Prior to the study, the ethics committee approval required for research was obtained from Alanya Alaaddin Keykubat University Faculty of Dentistry Clinical Research Ethics Committee with the decision number 10354421-2023/14–16. Individuals participating in the study were informed verbally and in writing and their consent was obtained before participation.

Ultrasonographic evaluation

Ultrasonographic examination of the patients in the study was performed with a Philips ClearVue 350 ultrasonography device and a high frequency linear scanning probe (7–12 MHz) in the Department of Oral and Maxillofacial Radiology. Masseter muscle thickness measurements were evaluated by the same investigator (M.N.K.) using the B-Mode of the device.

All ultrasonographic evaluations were conducted using a Philips ClearVue 350 ultrasound system equipped with a 7.5–12 MHz linear transducer, operating at a frequency of 10 MHz to ensure optimal resolution of superficial structures such as the masseter muscle. The scanning depth was set between 2.5 and 3.0 cm, adjusted individually to allow full visualization of the muscle from the skin surface to the mandibular ramus. The gain was standardized at 50–55 dB, with minor adjustments made when necessary to optimize image clarity. The focal zone was positioned at the midpoint of the masseter muscle to maximize image sharpness at the region of interest. To minimize muscle compression, only light and consistent pressure was applied with the probe. The ultrasound system was calibrated daily according to the manufacturer's guidelines to ensure measurement accuracy and consistency.

The masseter muscles of the patients were monitored both at rest and during contraction and thickness measurements were performed separately on the right and left sides for both groups. For the reliability and reproducibility of the measurements, the patients rested for 2 min each and the measurements were continued.

The thickest part of the masseter muscle was determined by palpation and the linear probe was positioned perpendicular to the ramus, and measurements were made from the mediolateral region of the mandibular ramus around the level of the occlusal plane.

The masseter muscle thickness of patients in a supine position was measured using ultrasound at a level halfway between the zygomatic arch and the gonial angle under both relaxation and clenching conditions. First of all, the patient was told not to touch his/her teeth during the resting position measurements and was asked to make a small amount of contact by releasing his/her lips. In this resting position of the jaw, the first measurement values were recorded separately on the right and left sides. Then, the patient was asked to clench the teeth as much as possible and the second values in the maximum contraction state were recorded separately on the right and left sides.

The measurements were made by positioning the probe perpendicular to the skin surface and applying a slight pressure on the muscle using water-based ultrasound gel and the patients rested for 2 min between these measurements to ensure reproducibility and prevent possible errors (Figs. 1 and 2).

Statistical analysis

The data obtained from the study were analyzed with IBM SPSS V23 package program. The conformity of the data to normal distribution was examined by Shapiro-Wilk test. Independent Samples t test was used to compare the data showing normal distribution according to paired groups, while Mann Whitney U test was used to compare the data not showing normal distribution according to paired groups. Pearson's correlation coefficient was used to examine the relationship of continuous parameters that fit the normal distribution, while Spearman's rho correlation coefficient was used to examine the relationship of continuous parameters that do not fit the normal distribution. Analysis results were presented as mean ± standard deviation and median (minimum- maximum) and significance level was taken as $p < 0.05$. Interclass correlation coefficients were calculated to evaluate intra-observer reliability for measurements taken from 10 randomly selected USG images.

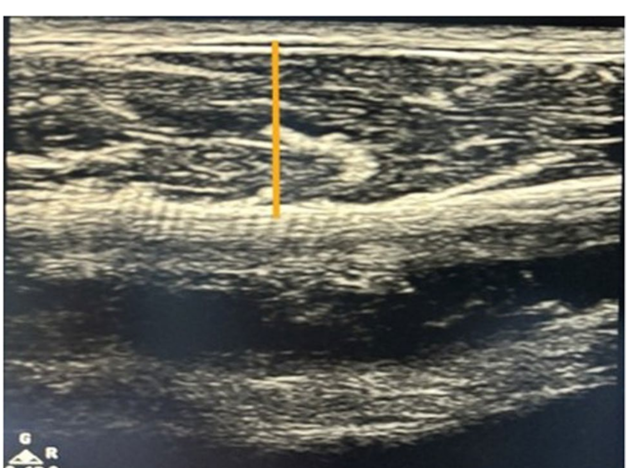

Fig. 1 Ultrasonographic image of the massater muscle at resting position

Results

Intra-observer coefficients values were calculated to be > 90%. When the quantitative data of the study and control groups were compared according to gender, resting and contraction masseter muscle thickness values were found to be higher in male patients than in female patients in both groups. Detailed numeric data of the measurements were presented in Table 1 and Table 2.

In the comparison of quantitative data according to the groups, no significant relationship was found between the groups and right or left side resting and contraction states (Table 3). In the mouth breathing group, there was no statistical difference in resting and contraction positions according to the group factor.

In the evaluation of the data of male patients according to the groups, a statistically significant difference was observed in the masseter muscle thickness values in the mouth breathing study group compared to the control group in both right and left side in resting and contracting positions (Table 4). The mean value of the thickness at rest on the right side was 1.255 cm in the study group and 1.39 cm in the control group and a statistically significant difference was observed between the values obtained ($p = 0.003$). Resting values on the left side were 1.2 cm in the study group and 1.35 cm in the control group and a statistical difference was found ($p = 0.004$). The maximum bite contraction values of the masseter muscles were 1.605 cm on the right side in the study group and 1.815 cm in the control group and a statistical difference was observed ($p = 0.004$). The left side contraction values were also measured as 1.575 cm in the study group and 1.785 cm in the control group and again the values obtained showed a difference according to the group factor ($p = 0.002$).

In addition, in female patients, thickness values at rest and contraction did not show any statistical difference on the right or left side according to the group factor (Table 5). The mean resting value on the right side was 1.152 cm in the study group and 1.111 cm in the control patients ($p = 0.304$). On the left side, these values were 1.12 cm in the study group and 1.114 cm in the control group ($p = 0.883$). No statistical difference was observed in the contraction values of the muscles on the right or left side in the female patient groups. The mean contraction values on the right side were 1.485 cm for the study group and 1.446 cm for the control group ($p = 0.406$), while on the left side these values were 1.444 cm for the study group and 1.443 cm for the control group ($p = 0.982$).

Finally, the relationship between the patients' ages and muscle thickness values was evaluated and no significant age-related change was observed in both groups ($p > 0.05$) (Table 6 and 7).

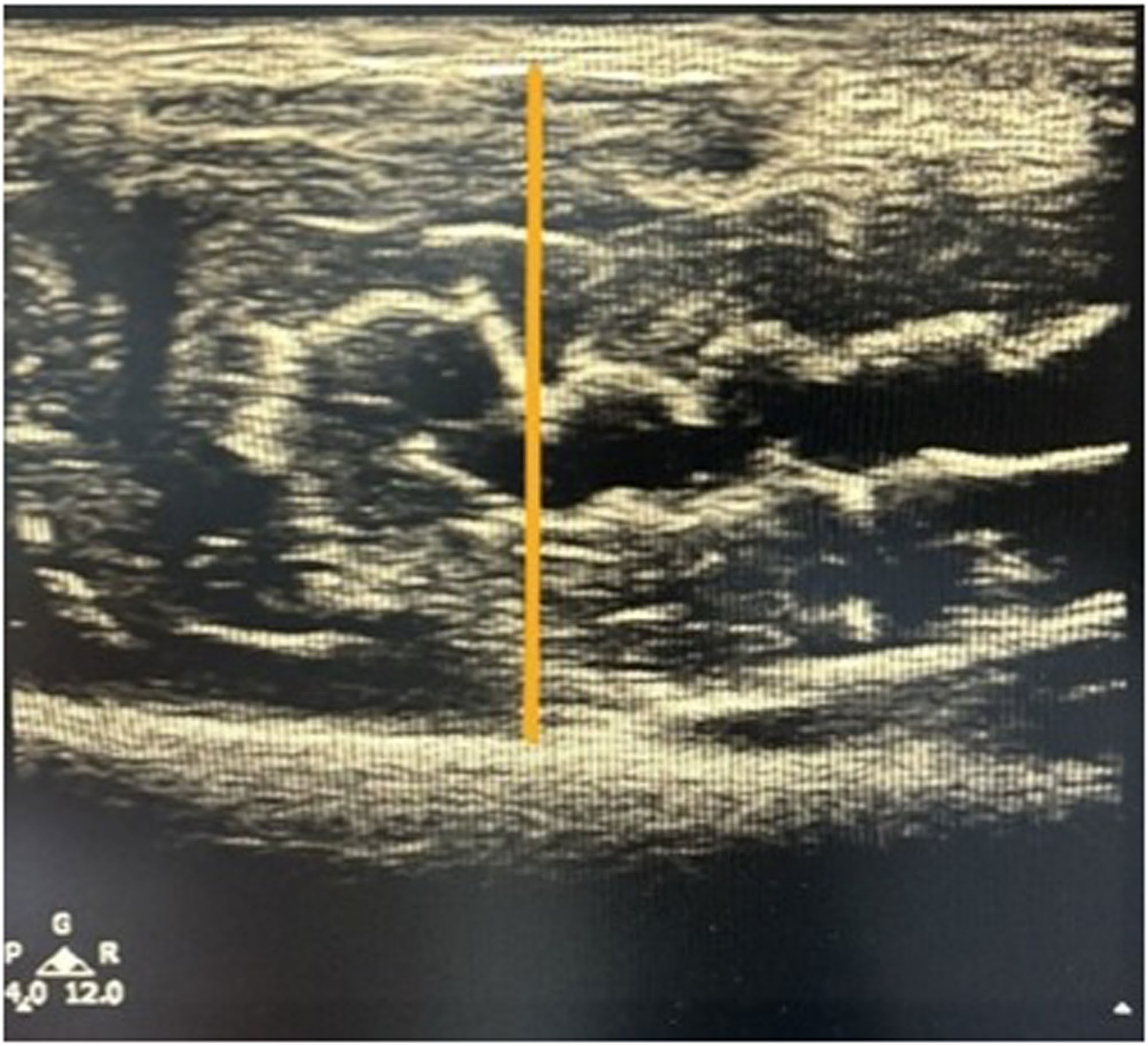

Fig. 2 Ultrasonographic image of the massater muscle in contraction

Table 1 Comparison of quantitative parameters by gender in the patient group

	Male	Female	Total	p
Right resting	1.255 (0.99–1.85)	1.145 (0.93–1.4)	1.21 (0.93–1.85)	0.015[x]
Left resting	1.2 (0.98–1.86)	1.09 (0.93–1.42)	1.16 (0.93–1.86)	0.014[x]
Right contraction	1.605 (1.34–2.3)	1.5 (1.19–1.9)	1.565 (1.19–2.3)	0.003[x]
Left contraction	1.575 (1.32–2.27)	1.445 (1.16–1.77)	1.53 (1.16–2.27)	0.003[x]

[x]Mann Whitney U Test was used. Mean ± standard deviation and (minimum – maximum) values were presented

Table 2 Comparison of quantitative parameters by gender in the control group

	Male	Female	Total	p
Right resting	1.415 ± 0.191	1.111 ± 0.147	1.257 ± 0.227	< 0.001[x]
Left resting	1.41 ± 0.226	1.114 ± 0.156	1.256 ± 0.242	< 0.001[x]
Right contraction	1.808 ± 0.205	1.446 ± 0.174	1.62 ± 0.262	< 0.001[x]
Left contraction	1.796 ± 0.228	1.443 ± 0.189	1.613 ± 0.273	< 0.001[x]

[x]Independent samples t Test was used. Mean ± Standard deviation values were presented

Discussion

Mouth breathing is associated with impaired function of the lips and perioral musculature, proclination of the anterior teeth, constriction of the maxillary dental arch, and reduced tone of the masticatory muscles [7, 8].

Table 3 Comparison of quantitative data by groups

	Patient	Control	Total	*p*
Right resting	1.21 (0.93–1.85)	1.27 (0.88–1.85)	1.225 (0.88–1.85)	0.338[x]
Left resting	1.184 ± 0.176	1.256 ± 0.242	1.22 ± 0.214	0.092[y]
Right contraction	1.565 (1.19–2.3)	1.58 (1.16–2.2)	1.58 (1.16–2.3)	0.347[x]
Left contraction	1.53 (1.16–2.27)	1.575 (1.15–2.3)	1.545 (1.15–2.3)	0.149[x]

[x]Mann Whitney U Test and [y] Independent samples t Test were used. Mean ± standard deviation and (minimum – maximum) values were presented

Table 4 Comparison of quantitative parameters according to groups in male

	Patient	Control	Total	*p*
Right resting	1.255 (0.99–1.85)	1.39 (1.06–1.85)	1.3 (0.99–1.85)	0.003[x]
Left resting	1.2 (0.98–1.86)	1.35 (0.96–1.83)	1.3 (0.96–1.86)	0.004[x]
Right contraction	1.605 (1.34–2.3)	1.815 (1.4–2.2)	1.7 (1.34–2.3)	0.004[x]
Left contraction	1.575 (1.32–2.27)	1.785 (1.35–2.3)	1.64 (1.32–2.3)	0.002[x]

[x]Mann Whitney U Test was used. Mean ± standard deviation and (minimum – maximum) values were presented.

Table 5 Comparison of quantitative parameters according to groups in female

	Patient	Control	Total	*p*
Right resting	1.152±0.127	1.111±0.147	1.131±0.138	0.304[x]
Left resting	1.12±0.138	1.114±0.156	1.117±0.146	0.883[x]
Right contraction	1.485±0.151	1.446±0.174	1.464±0.163	0.406[x]
Left contraction	1.444±0.15	1.443±0.189	1.444±0.169	0.982[x]

[x]Independent samples t Test was used. Mean ± standard deviation values were presented

Table 6 Examining the relationship between age and quantitative parameters in the patient group

	Age	
	r	p
Right resting	0.264	0.064[x]
Left resting	0.162	0.262[y]
Right contraction	0.161	0.265[x]
Left contraction	0.064	0.657[x]

[x]Spearman's rho correlation coefficient and [y] Pearson correlation coefficient tests were used

Table 7 Examining the relationship between age and quantitative parameters in the control group

	Age	
	r	p
Right resting	−0.027	0.850[x]
Left resting	0.082	0.569[x]
Right contraction	−0.105	0.468[x]
Left contraction	−0.083	0.567[x]

[x]Pearson correlation coefficient test was used

Among these, the masseter muscle plays a particularly critical role, often regarded as a fundamental component of the masticatory system, and has consequently been the focus of numerous scientific investigations. Visualization of the functional dynamics and morphological features of the masseter muscle provides valuable insights that may enhance clinical decision-making in dental practice [11]. For imaging soft tissues such as the masticatory muscles, ultrasonography offers notable advantages, including the absence of ionizing radiation exposure, the ability to obtain reproducible real-time images, and greater cost- and time-efficiency compared to alternative imaging modalities [12, 13].

Ultrasonography represents one of the most frequently utilized imaging modalities for the assessment of masticatory muscles and the evaluation of muscle dimensions. However, its applicability is primarily limited to superficial muscles, such as the masseter and temporalis, whereas reliable visualization and measurement of the lateral and medial pterygoid muscles remain challenging. Despite these limitations, ultrasonography has been demonstrated to be effective in assessing the structural characteristics and thickness of the masseter muscle, and its use is regarded as both feasible and practical. Moreover, ultrasonographic imaging enables the quantification of volumetric parameters, including muscle thickness, length, and cross-sectional area [14, 15]. There are several studies in the literature in which masseter muscle thicknesses were evaluated using ultrasound imaging. In a study by Najm et al. [19] 40 male patients were divided into groups with and without bruxism and their muscle thicknesses were measured in resting and contracting positions and the masseter muscle thickness values of the group with bruxism were found to be higher. Temporomandibular joint irregularities are often associated with bruxism and may lead to abnormalities in the skeletal musculature. Since muscle thickness increases are a possible condition in patients with bruxism and temporomandibular joint problems, these patient groups were not included in our study.

In a study conducted by Kiliaridis et al. [12] on 20 males and 20 females, healthy and toothed patients, it was reported that masseter thicknesses were related to facial morphology, especially in female patients, and that the thinner the muscle thickness, the longer the facial structure. In addition, as a result of this study, in parallel with our findings, the values of male patients were measured higher than female patients in both resting and contracted positions. While the analysis demonstrated a statistically significant difference in the male subgroup, no such difference was observed among female participants. This discrepancy may be attributable to sexual dimorphism in craniofacial morphology and masticatory muscle characteristics, as men generally present with greater muscle mass and thickness, which may render differences more detectable. Hormonal influences, such as the modulatory role of estrogen on muscle tissue, might also contribute to the absence of significance in females.

There are various studies in the literature on the relationship of mouth breathing with masticatory muscles and its effects on the masseter muscle [20–22]. Nagaiwa et al. [20] examined the effect of mouth breathing on chewing efficiency in a study. In this study, it was stated that mouth breathing would cause inhibition of the masticatory function by competing with the respiratory function and would negatively affect masticatory efficiency.

In a study by Ikenaga et al. [21] in 45 adult patients, the effect of mouth breathing on masticatory muscles was evaluated by electromyography measurements. He reported that mouth breathing significantly prolonged resting and total chewing time, but the duration of active chewing was significantly shorter than nasal breathing. This study evaluated that mouth breathing decreases the activity of the masticatory system, the degree of vertical occlusal force on the posterior teeth and the activation of the masseter muscle. Considering that the oral cavity is involved in both breathing and chewing functions, it is difficult to carry out both functions at the same time. Since the breathing function is more important than the chewing function according to the body's survival instinct, it is conceivable that chewing movements would be interrupted during breathing.

Similarly, the study of Hsu et al. [22] stated that mouth breathing would reduce the number of chewing cycles by decreasing masticatory activity and negatively affect the electromyographic activation values of the masseter muscle, and this may affect the vertical position of the posterior teeth and may be a factor in the development of open bite in the individual. However, many studies have indicated that mouth breathing causes an increase in masseter muscle thickness, potentially due to increased muscle tension [12, 15, 19]. Despite these studies, in the present study, the masseter muscle thickness of patients who mouth breathing was found to be thinner than that of the control group. It is thought that this may be due to atrophy of the masseter muscle.

In our study, the masseter muscle thickness values of the mouth breathing male patient group were found to be significantly lower than the control male group according to the side and contraction status variables, while no significant value was observed in the comparison of the female patient group and the control group. In the gender variable, the muscle thicknesses of male patients were found to be significantly higher than those of female patients on both sides and in both positions. This study has several limitations that should be acknowledged. First, the sample size, although adequate for preliminary analysis, was relatively small and limited to a single-center population, which may restrict the generalizability of the findings to broader populations. Second, potential confounding factors such as nutritional status, body mass index, occlusal characteristics, and daily functional habits (e.g., chewing preference or parafunctional activities) were not fully controlled, which could have affected muscle morphology and function. When the results of this study are evaluated, it can be stated that mouth breathing causes a negative effect on masticatory functions by creating an obstacle to normal physiology in the masticatory system and decreases the activation of the masseter muscle, which is one of the main elements of masticatory function, and more comprehensive studies with a larger population are recommended.

Conclusion

It can be stated that mouth breathing causes a negative effect on masticatory functions by creating an obstacle to normal physiology in the masticatory system and reduces the activation of the masseter muscle, which is one of the main elements of masticatory function.

Abbreviations

USG Ultrasonography
Mhz Megahertz

Acknowledgements
Not applicable.

Informed consent
All participants were informed about the purpose and procedures of the study, and written informed consent was obtained from each participant prior to inclusion in the study.

Authors' contributions
MNK: Design, Writing, Material Preparation, Data collection, Analysis, Review Final Version **TC** : Design, Data collection, Review, Final Version.

Funding
Not applicable.

Data availability
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
All procedures performed in studies involving human participants were in accordance with the athical standarts of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Ethics committee approval was received for this study from Alanya Alaadin Keykubat University Faculty of Medicine Clinical Research Ethics Committee (Clinical trial number: 10354421-2023/14–16).

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Conflict of interest
Authors disclosed no relevant relationships.

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