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Correlation between the Thickness and Anterior-Posterior Width of the Masseter Muscle in Ultrasonography with the Intermolar Width in Maxilla and Mandible

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Abstract:

Objective(s): The interplay between masticatory muscle function and dental arch size holds considerable significance within the discipline of orthodontics. This research endeavored to quantify masseter muscle dimensions via ultrasonography (USG) and subsequently analyze their correlative relationship with dental arch width. **Methods:** 45 participants were enrolled in this cross sectional study, stratified by gender and age cohorts. Bilateral USG assessments, utilizing a 7.5 MHz linear transducer, were conducted to quantify masseter muscle thickness and anterior-posterior (AP) width during both relaxed and clenched states. Intermolar width was determined through direct measurement with a metal caliper on dental casts of the maxillary and mandibular arches. Independent samples t-tests were employed to analyze mean differences between male and female subjects. The association between masseter muscle dimensions (thickness and width) and intermolar width was evaluated using Spearman's rank correlation coefficient and Pearson's correlation coefficient, as appropriate at $p<0.05$. **Results:** The study cohort comprised 20 females and 25 males within the age range of 16 to 30 years. Statistically significant sexual dimorphism was observed, with males demonstrating substantially greater masseter muscle thickness and AP width compared to females in both relaxed and clenched states ($p < 0.001$). Consistent with expectations, males demonstrated statistically significant greater intermolar widths in both the maxilla and mandible ($p < 0.001$). Across the entire study population, a statistically significant positive correlation was identified between masseter muscle thickness and intermolar width ($p < 0.05$). Specifically, individuals exhibiting larger masseter muscle dimensions presented with correspondingly increased intermolar widths in both the maxillary and mandibular arches. However, when these variables were stratified by gender or age group, no statistically significant correlations were observed ($p > 0.05$).
Conclusion: USG is validated as a safe and reproducible technique for the objective measurement of masseter muscle thickness.

Keywords: Masseter Muscle; Dental Arch; Ultrasound Imaging; Muscle Anatomy

Introduction

The interplay between masticatory muscle function and dental arch dimensions holds significant clinical relevance within the discipline of orthodontics. Specifically, the elucidation of the influence exerted by muscle activity, notably that of the masseter muscle, upon dental arch width and overall maxillomandibular alignment, is crucial. Such an understanding possesses substantial implications for the refinement of orthodontic diagnostic protocols and the formulation of comprehensive treatment strategies.[1] Muscle imbalances, stemming from conditions like bruxism or other functional abnormalities, can precipitate alterations in the developmental trajectory of the jaw and dental arches. Such deviations in growth patterns can introduce complexities into orthodontic treatment planning and execution. Masseter muscle hypertrophy, as a specific example, has the potential to alter the transverse dimension of the dental arch, consequently affecting the occlusion and the necessity for orthodontic intervention[2]. Through the quantitative assessment of muscle thickness and functional parameters, orthodontists are enabled to acquire critical information regarding the etiological factors influencing dental development. This enhanced understanding facilitates the implementation of personalized treatment strategies that effectively target both the skeletal and muscular determinants of malocclusion. The current research, aimed to assess the relationship between muscular function and craniofacial morphogenesis, consequently allowing to refine orthodontic treatment protocols and improve patient outcomes[3].

Dental arch development is a complex, multifactorial phenomenon influenced by a combination of genetic predispositions and environmental determinants, encompassing muscular, functional, and localized factors. Optimal dental arch morphology is characterized by proportional relationships between the maxillary and mandibular structures and the surrounding musculature and craniofacial framework.[3,4] A comprehensive review by Pepicelli et al. (2005) indicated that individuals exhibiting robust or hypertrophic mandibular musculature tend to present with increased transverse craniofacial dimensions and a propensity for parallelism between the mandibular and occlusal planes, as well as between the jaw bases.[2]

Masticatory musculature is integral to oral functionality, encompassing three-dimensional mandibular kinematics, dental arch morphology, and alveolar process thickness. Specifically, Katsaros et al. [4] posited that alterations in masticatory muscle function exert influence on the transverse development of the cranium, particularly within regions subjected to direct muscular forces, such as the insertion sites of the masseter muscle. Bruxism is clinically defined as repetitive masticatory muscle activity, encompassing the parafunctional behaviors of teeth clenching, grinding, and gnashing. Scholarly literature contains numerous investigations exploring the potential correlation between bruxism and various psychological constructs, including personality traits, psychosocial stressors, and anxiety levels. The sequelae of bruxism can manifest in a spectrum of detrimental oral and musculoskeletal conditions, such as dental fractures, tooth abrasion, increased tooth mobility, complications associated with prosthetic dental appliances, temporomandibular joint disorders (TMD), masticatory muscle pain and fatigue, and masseter muscle hypertrophy.[5,6]

Contemporary research has established muscle thickness as a relevant metric for assessing jaw muscle activity. Various imaging and physiological techniques are employed to evaluate the dimensions and functional characteristics of these muscles. Ultrasonography (USG) presents a viable alternative to other imaging modalities, offering accessibility, reliability, and a non-invasive approach. Notably, it surpasses multi-detector CT (MDCT), cone-beam CT (CBCT), and MRI in its capacity to delineate the internal echogenic architecture of muscular tissues.[7] In a comparative study conducted by Radsheer et al. (1994), the accuracy and reproducibility of USG in quantifying mid-belly masseter muscle thickness were established relative to MRI. The findings of that research validated USG as a precise imaging technique.[8] In USG images, healthy muscle tissue typically exhibits a heterogeneous pattern of low echogenicity, interspersed with occasional hyperechoic fascia layers.[9] Given the established correlation between masticatory muscle function and transverse cranial dimensions in animal models, a comparable association may be hypothesized to exist regarding dental arch width in human subjects.[10] While prior studies had explored the relationship between masseter muscle thickness and arch dimensions, no research had comprehensively evaluated the concurrent relationship of both masseter muscle thickness and anterior-posterior (AP) width with the intermolar width of both the maxilla and mandible.

This investigation was conducted to quantify the masseter muscle's thickness and width using USG and to examine the influence of this muscle on dental arch width during resting and clenched states.

Methods

Ethical Approval

This study employed a cross-sectional, analytical-descriptive design. Adherence to ethical principles was paramount, guaranteeing that USG procedures posed no radiation-induced harm to participants. The research protocol received approval from the Ethics Committee of the School of Dentistry, Shahid Beheshti University (code: IR.SBMU.DRC.REC.1400.134) and was executed in accordance with the Declaration of Helsinki and its subsequent amendments. Institutional policy mandated informed consent from all participants, explicitly detailing the benefits and risks associated with each procedure, and ensuring approval for the utilization of their data.

Sample Size

A cohort of patients receiving orthodontic therapy at the Department of Orthodontics, School of Dentistry, Shahid Beheshti University of Medical Sciences, from 2021 to 2022, was subsequently referred to the Department of Oral and Maxillofacial Radiology for examination. The required sample size, determined through power analysis, was calculated to be 45 participants. This calculation was predicated on the assumption of a minimum clinically relevant correlation coefficient (r) of 0.35, a significance level (α) of 0.05, and a statistical power of 0.84.

Inclusion Criteria

The study population comprised of individuals aged 16 to 30 years, selected on the basis that the positional stability of the first molars is typically achieved by the age of 16, resulting from the interaction of soft and hard tissues during normal growth. Furthermore, participants were required to demonstrate good physical health.[11]

Exclusion Criteria

The evaluation of patients had to encompass a comprehensive medical history, including previous systemic diseases, prior orthodontic interventions, the presence of discrepancies and pathological conditions, a history of head and facial trauma, muscular paralysis, and neurological disorders, as well as an assessment of malocclusion, and functional and skeletal abnormalities.

Patient Positioning

Subjects were positioned in an erect posture with the head in a natural, unforced orientation, fixating on a designated point located two meters anteriorly. For resting state measurements, participants were instructed to achieve a relaxed mandibular posture, involving gentle oral closure, deglutition of saliva, and light occlusal contact of the posterior dentition. For clenching state measurements, participants were directed to exert maximal voluntary contraction of the masticatory muscles, resulting in forceful occlusion of the posterior teeth.

For each positional assessment, the transducer was positioned over the masseter muscle region of the face. Precise angular adjustments of the transducer were performed to optimize the echo return from the mandibular ramus, with perpendicular alignment to this anatomical landmark being the criterion for optimal signal acquisition. All measurements were conducted utilizing the transverse plane of facial imaging. To mitigate potential measurement variability, a repeated imaging sequence was executed by the same operator following a five-minute interval. Subsequently, the intraclass correlation coefficient (ICC) was computed to determine the reliability and consistency of the obtained measurements.

Measurements

Bilateral masseter muscle imaging was performed utilizing a 7.5 MHz linear probe ultrasound system (myLab, Esaote Co., Italy), facilitated by Aquasonic 100 water-soluble gel, and conducted by a specialized oral and maxillofacial radiologist.

Quantitative assessment of the masseter muscles was achieved through B-mode USG, wherein linear dimensions, specifically muscle thickness and AP width, were measured with a digital linear caliper exhibiting a precision of 0.01 cm. Intra-examiner reliability for these measurements was established by repeated assessments of 10 randomly selected subjects, with a two-week interval between the initial and subsequent evaluations.

USG assessment of masseter muscle thickness was performed at 2-mm intervals across the posterior, middle, and anterior regions, during both relaxed and clenched states. Digital ultrasound software facilitated data acquisition, and mean thickness values were subsequently computed (Figure 1). To determine the AP dimension, the boundaries of the masseter muscle were delineated, and the linear distance between these points was quantified (Figure 2, A and B). In instances where muscle elongation was observed, either at rest or during clenching, the AP width measurement was adjusted utilizing the Ramus index to account for the altered muscle morphology (Figure 2, C and D).

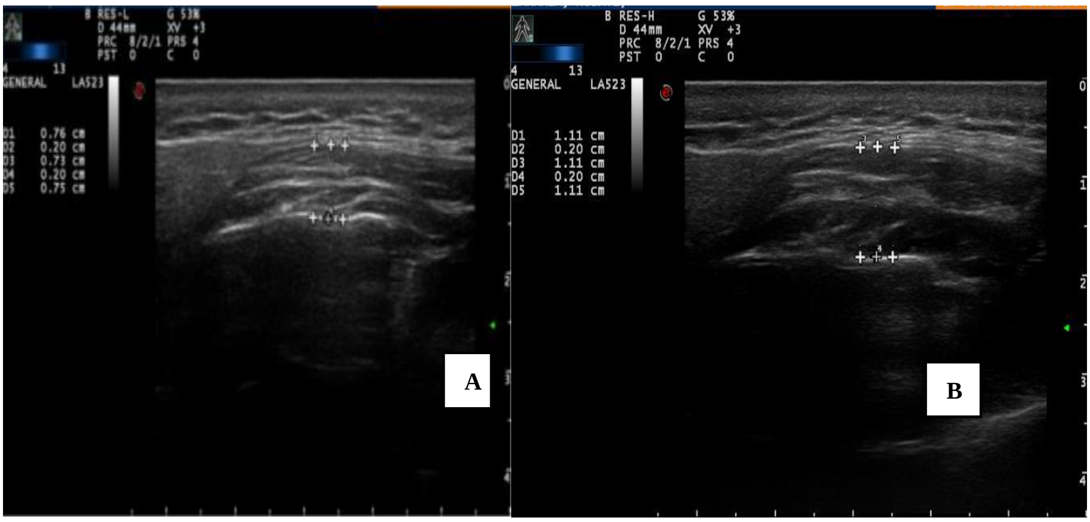

Figure 1: Measurement of masseter muscle thickness in the middle and 2 mm anterior and posterior to it in the (A) rest state and (B) clenched state

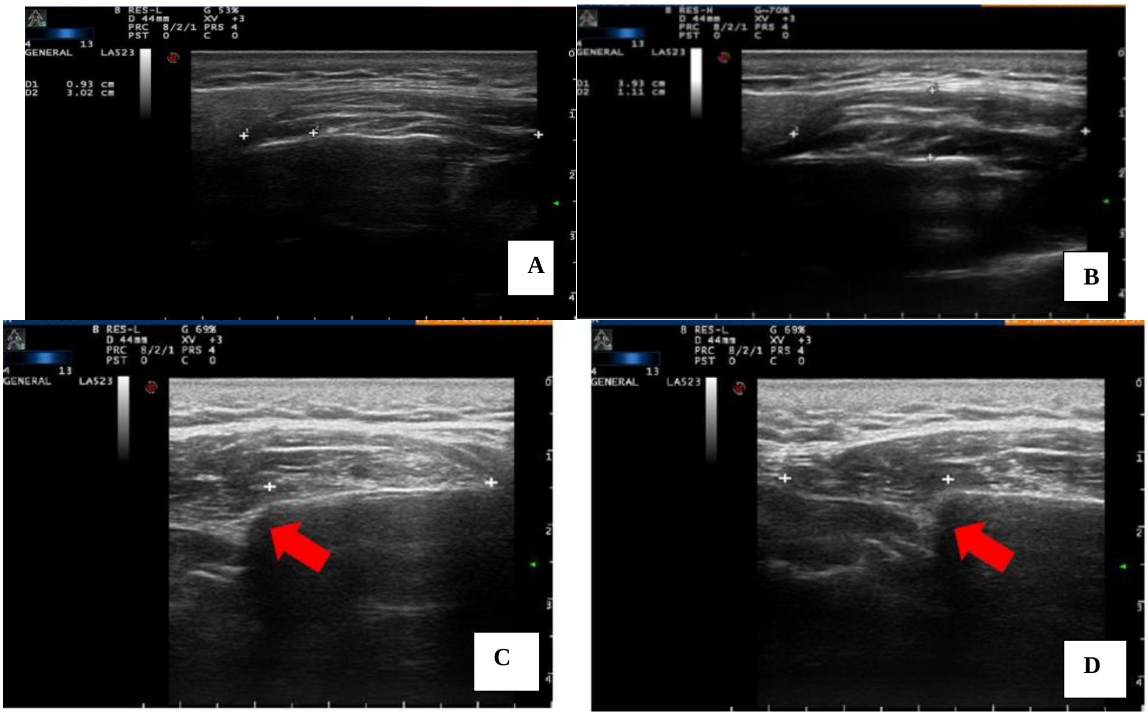

Figure 2: Measurement of antero-posterior width of the masseter muscle in the (A) rest state, (B) clenched state, and (C and D) utilization of the Ramus index (red arrow) for measuring the ant-pos width of the elongated masseter muscle

Intermolar width was determined by fabricating alginate impressions of the maxillary and mandibular arches, which were then used to create dental casts. Measurements were subsequently obtained using digital calipers. Specifically, the distance between the central fossae of the permanent maxillary first molars and the distance between the distobuccal cusp tips of the permanent mandibular first molars were recorded to quantify intermolar width (Figure 3).

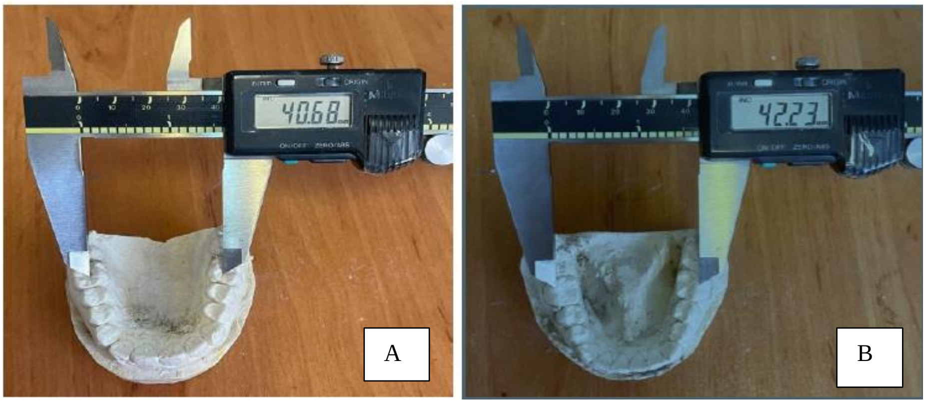

Figure 3: Measurement of intermolar width using electronic calipers. (A) Maxillary arch, (B) Mandibular arch

Statistical Analysis

Statistical analyses were conducted utilizing SPSS software, version 27 (SPSS Inc., Chicago, IL, USA). The normal distributaion of data was assessed through the application of the Shapiro-Wilk test and visual inspection of probability plots. Descriptive statistics, encompassing means, standard deviations, and percentages, were calculated to summarize the dataset. To evaluate the intra-rater reliability of the masseter muscle measurements, the ICC was determined. ICC values exceeding 0.83 were interpreted as indicative of excellent reliability.

In this study, the Chi-square test, with a predetermined significance level of $p = 0.05$, was utilized to analyze categorical data. For continuous variables, the distribution of data was evaluated for normality to guide the selection of appropriate statistical methods. Parametric tests, specifically the independent t-test, were applied for comparisons between male and female participants when the data exhibited a normal distribution. Conversely, non-parametric tests, notably the Mann-Whitney U test, were employed for gender-based comparisons of continuous variables that deviated from a normal distribution.

The examination of the associations between masseter muscle dimensions and intermolar width was performed using Pearson's correlation coefficient for data exhibiting normal distribution, and Spearman's rank correlation coefficient for data violating normality assumptions. To investigate potential age-related variations in these associations, subgroup analyses were conducted within discrete age strata (16-20, 21-25, and 26-30 years), employing the aforementioned correlation methodologies.
Statistical significance was established at a threshold of $p < 0.05$. To enhance clarity, p-values exceeding 0.05 were reported to three decimal places. All statistical tests were conducted using a two-tailed approach. These rigorous methodological practices were implemented to ensure the accuracy and reliability of the analysis concerning the relationships between masseter muscle measurements and dental arch dimensions. Subsequently, variables demonstrating adherence to the normality assumption were subjected to parametric statistical analyses, specifically the independent samples t-test for the purpose of comparing means and the Pearson correlation coefficient to examine the nature of relationships between variables. In instances where variables deviated from a normal distribution, non-parametric statistical methodologies were employed. Specifically, the Mann-Whitney U test was utilized for the comparison of means, and Spearman's rank correlation coefficient was calculated to assess relationships between variables. This methodological approach ensured the application of statistical tests congruent with the data's distributional characteristics. Notably, the overall findings demonstrated robustness, exhibiting consistent results across both parametric and non-parametric analytical frameworks.

Results

Intra-operator Reliability

For 10 patients, duplicate measurements were obtained, and the reliability of these measurements was assessed using ICCs. The majority of measured variables exhibitedrite: substantial reliability between the first and second replicates, as evidenced by ICC values ranging from 0.83 to 0.90 or higher.

Demographic Results

A cohort of 45 participants was recruited, comprising 20 females (44.5%) and 25 males (55.5%), with ages ranging from 16 to 30 years. The participants were stratified into three age groups: 16-20 years, 21-25 years, and 26-30 years.

Masseter Muscle Measurements

The mean muscle thickness observed during a state of rest was quantified as 8.94 ± 1.76 mm..The mean muscle thickness, assessed during clenching, was determined to be 13.48 ± 2.59 millimeters. The data stratified by gender is presented in Table 1.
The mean AP width of the muscle under resting conditions was determined to be 53.40 ± 5.53 mm. The data stratified by gender is presented in Table 1. The mean AP muscle width during clenching was quantified as 45.70 ± 3.90 mm. Stratified by gender, female participants exhibited mean right-sided and left-sided AP muscle widths of 43.11 ± 2.49 mm and 44.65 ± 5.03 mm, respectively. Male participants demonstrated mean right-sided and left-sided AP muscle widths of 47.00 ± 3.99 mm and 47.32 ± 4.13 mm, respectively (Table 1).

Table 1- Masseter muscle thickness in the rest and clenched condition by sex and side

Muscle thickness in Rest condition												
Thickness rest	Female (N=20)				Male (N = 25)				Total (N =45)			
	Mean	Std.	Min.	Max.	Mean	Std.	Min.	Max.	Mean	Std.	Min.	Max.
Right	7.73	1.17	5.9	9.9	9.28	1.63	5.6	12.9	8.59	1.62	5.6	12.9
Left	7.95	1.23	5.5	9.8	10.39	2.17	7.1	15.3	9.30	2.17	5.5	15.3
Average right and left	7.83	0.994	5.7	9.8	9.83	1.75	7.1	13.6	8.94	1.76	5.7	13.6
Muscle thickness in Clenched condition												
Thickness clenched	Female				Male				Total			
	Mean	Std.	Min.	Max.	Mean	Std.	Min.	Max.	Mean	Std.	Min.	Max.
Right	11.41	1.71	7.8	14.4	14.5	2.79	10.3	20.6	13.13	2.81	7.8	20.6
Left	12.27	1.59	9.6	14.7	15.07	2.65	11.3	21.2	13.83	2.62	9.6	21.2
Average right and left	11.84	1.52	9.6	14.05	14.78	2.55	11.4	20.1	13.48	2.59	9.6	20.1

Ant-pos width of the muscle in Rest Condition												
width rest	Female (N = 20)				Male (N = 25)				Total (N = 45)			
	Mean	Std.	Min.	Max.	Mean	Std.	Min.	Max.	Mean	Std.	Min.	Max.
Right	50.16	4.48	41.7	56.7	55.09	6.10	45.1	67.1	52.9	5.93	41.7	67.1
Left	51.06	5.10	42.6	61.3	56.16	5.85	45.4	68.1	53.896	6.04	42.6	68.1
Average right and left	50.61	4.52	42.6	58	55.626	5.31	46.75	67.6	53.40	5.53	42.6	67.6
Anterior-posterior width of the muscle in Clenched Condition												
Width clench	Female				Male				Total			
	Mean	Std.	Min.	Max.	Mean	Std.	Min.	Max.	Mean	Std.	Min.	Max.
Right	43.11	2.49	38.1	48.2	47.00	3.99	38.5	55.5	45.27	3.90	38.1	55.5
Left	44.65	5.03	39.8	63	47.32	4.13	41.4	55.4	46.13	4.70	39.8	63
Average right and left	43.87	3.30	39.1	54.85	47.16	3.78	40.5	54.5	45.70	3.90	39.1	54.85

Maxillary and Mandibular Intermolar Width

The mean intermolar width score of both jaws was measured as 47.10 ± 3.10 mm. The mean intermolar width scores of the maxilla and mandible were 45.29 ± 2.28 and 46.13 ± 2.54 mm in females and 48.5 ± 2.4 and 49.49 ± 2.69 mm in males, respectively (Table 2).

Table 2- Average intermolar width by sex

Intermolar width	Female (N = 20)				Male (N = 25)				Total (N = 45)			
	Mean	Std.	Min.	Max.	Mean	Std.	Min.	Max.	Mean	Std.	Min.	Max.
maxilla	45.29	2.28	41.2	49	48.5	2.46	43	54.5	47.07	2.86	41.2	54.5
mandible	46.13	2.54	42	50	49.49	2.69	45.5	55.1	47.10	3.10	42	55.1

The Correlation between the Masseter Muscle Measurements and Intermolar Width with Gender

An independent samples t-test was utilized to assess disparities in mean masseter muscle thickness and AP width between male and female subjects, both at rest and during clenching. The analysis demonstrated statistically significant inter-gender differences in both parameters, with males exhibiting consistently larger values bilaterally ($p < 0.001$ for thickness; $p < 0.05$ for AP width) (Table 3). This observation aligned with the comparative analysis of intermolar width in the maxilla and mandible, where male participants also displayed significantly elevated values compared to their female counterparts ($p < 0.001$).

Statistical analysis employing independent t-tests demonstrated a significant association between gender and masseter muscle thickness, both at rest and during clenching, bilaterally ($p < 0.001$). Furthermore, a statistically significant relationship was identified between gender and the AP width of the masseter muscle ($p < 0.05$). The findings indicated that males exhibited greater masseter muscle thickness and AP width compared to females in both resting and clenched states (Table 3).

Based on the results of the independent t-test, there was also a significant relationship between the gender of the participants and the intermolar width in both maxilla and mandible ($P<0.001$) (Table 3).

Table 3- The relationship between the masseter muscle thickness, ant-post width of the muscle, intermolar width, and gender in rest and clenched conditions on both sides

Independent sample t-test	t-test for Equality of Means				
	Sig. (2-tailed)	Mean Diff.	Std. Error Diff.	95% CI	
				Lower	Upper
Right thickness (rest)	0.001	-1.54	0.43	-2.41	-0.67
Left thickness (rest)	0.000	-2.44	0.51	-3.48	-1.40
Average right and left thickness (rest)	0.000	-1.10	0.41	-2.83	-1.16
Right thickness (clenched)	0.000	-3.08	0.67	-4.44	-1.72

Left thickness (clenched)	0.000	-2.79	0.63	-4.08	-1.50
Average right and left thickness (clenched)	0.000	-2.94	0.61	-4.17	-1.70
Independent sample T-test	t-test for Equality of Means				
	Sig. (2-tailed)	Mean Diff.	Std. Error Diff.	95% CI	
				Lower	Upper
Right width (rest)	0.004	-4.93	1.63	-8.22	-1.63
Left width (rest)	0.004	-5.09	1.65	-8.44	-1.74
Average right and left width (rest)	0.002	-5.01	1.49	-8.02	-2.00
Right width (clenched)	0.000	-3.89	1.02	-5.96	-1.83
Left width (clenched)	0.056	-2.67	1.36	-5.43	.07
Average right and left width (clenched)	0.004	-3.30	1.07	-5.45	-1.12
Independent sample T-test	t-test for Equality of Means				
	Sig. (2-tailed)	Mean Diff.	Std. Error Diff.	95% CI	
				Lower	Upper
Maxillary intermolar width	0.000	-3.21	.71	-4.65	-1.76
Mandibular intermolar width	0.000	-3.36	.78	-4.95	-1.77
Average intermolar width	0.000	-3.28	.72	-4.75	-1.82

This study examined the correlation between masseter muscle dimensions and intermolar width. Employing both Pearson and Spearman correlation analyses, the findings revealed no statistically significant association between masseter muscle thickness and intermolar width in either the maxilla or mandible, nor across gender groups, under resting and clenching conditions bilaterally ($P > 0.05$). Nevertheless, when gender was not considered, a significant positive correlation was observed between masseter muscle thickness on the right and left sides and intermolar width in both resting and clenching states ($P < 0.05$). Specifically, increased masseter muscle thickness, regardless of resting or clenching state, was associated with a larger intermolar width in both the maxilla and mandible (Figure 4).

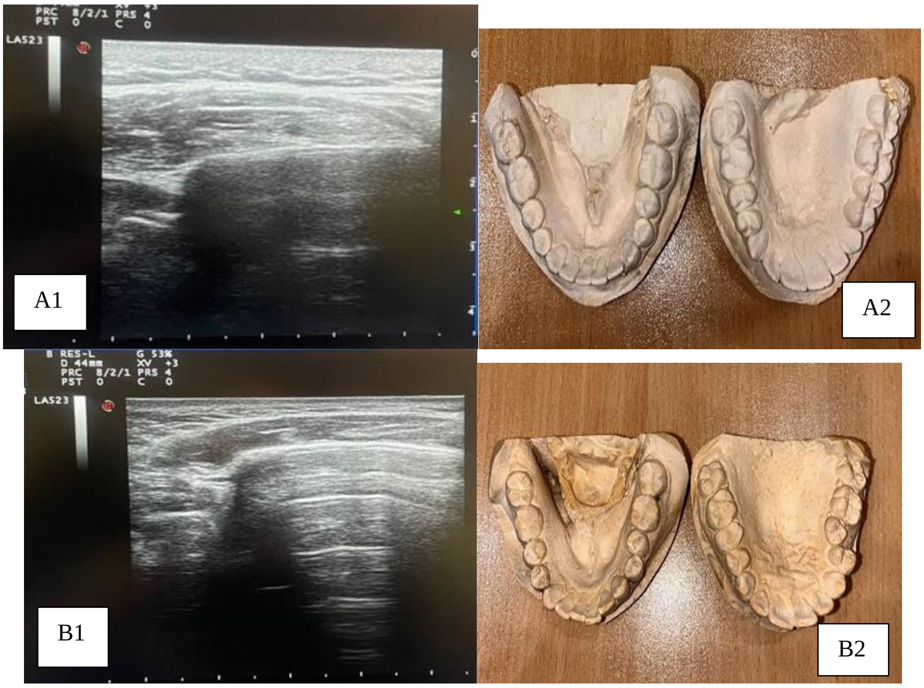

Figure 4: The relationship between masseter muscle thickness and intermolar width: Muscle with high thickness in USG (A1) and corresponding wide intermolar width on dental cast (A2), Muscle with low thickness in USG (B1) and corresponding low intermolar width on dental cast(B2)

The Correlation between the Masseter Muscle Measurements and the Intermolar Width by Jaw and Gender in Each Age Group

This study employed a cohort design, stratifying participants into three age brackets: 16-20 years, 21-25 years, and 26-30 years. Within each age stratum, the investigation aimed to determine the correlation between masseter muscle thickness and intermolar width, accounting for both mandibular and maxillary dimensions, as well as gender. Utilizing Pearson's correlation coefficient, the analysis revealed no statistically significant association between masseter muscle thickness and intermolar width in either the maxilla or mandible, across all age groups, for both male and female participants, and bilaterally ($p > 0.05$). The AP dimension of the masseter muscle was evaluated using a methodology analogous to that employed for assessing correlations in masseter muscle thickness. Statistical analysis, utilizing both Pearson and Spearman correlation coefficients, revealed no statistically significant association between the AP width of the masseter muscle and the intermolar width of either the maxilla or mandible. This absence of correlation was consistent across all age cohorts, in both resting and clenched jaw positions, for both genders, and in bilateral measurements ($P > 0.05$). This study examined the association between masseter muscle dimensions and intermolar width. Utilizing Pearson and Spearman correlation analyses, no statistically significant correlations were identified between masseter muscle thickness and intermolar width in either the maxilla or mandible. Additionally, no significant relationships were observed when stratified by gender, across both resting and clenching states, bilaterally ($P > 0.05$).

The AP dimension of the masseter muscle was evaluated using a methodology consistent with that employed for masseter muscle thickness assessment. Statistical analyses, specifically utilizing Pearson's and Spearman's correlation coefficients, revealed no statistically significant correlations ($P > 0.05$) between the AP width of the masseter muscle and the intermolar widths of the maxilla and mandible. This lack of significant association was observed across all age cohorts, under both resting and clenched jaw conditions, for both genders, and in bilateral measurements.

A statistically significant positive correlation was observed between masseter muscle thickness, bilaterally, and the intermolar width of both the maxilla and mandible. This relationship was demonstrated by p-values below the conventional threshold of 0.05, indicating a robust association between these variables. A statistically significant positive correlation ($p < 0.05$) was observed between the AP width of the masseter muscle and the intermolar width of both the maxilla and mandible. The correlation between these variables in the right maxillary region approached significance ($p = 0.06$).

Discussion

The present research sought to ascertain the correlation between masseter muscle thickness and AP dimension, quantified via USG imaging, and intermolar distance as determined from dental casts. The analysis revealed a positive association whereby subjects displaying increased masseter muscle thickness and AP width, both at rest and during clenching, also presented with correspondingly larger intermolar widths in the maxillary and mandibular arches. These observations underscore the substantial impact of masseter muscle morphology on dental arch configuration.

The influence of jaw musculature on the etiology of malocclusion and the propensity for post-orthodontic relapse is well-established. Relapse following orthodontic intervention, a clinically significant concern, exhibits a broad range of occurrence, spanning from 14% to 70% .[12] Notably, individuals characterized by elevated masseteric activity demonstrate heightened vulnerability to relapse. This susceptibility is attributed to the tendency for molar depression during masticatory and deglutitive functions, thereby impeding the achievement and maintenance of molar extrusion and posterior mandibular rotation. Furthermore, in brachyfacial phenotypes exhibiting robust masseteric function, premolar extraction procedures may exacerbate reductions in facial height and lead to a deepening of the bite, posing considerable challenges to treatment planning and long-term stability.[13]

Existing literature establishes a relationship between masseter muscle thickness and mandibular development. Specifically, hypertrophy of the masseter muscle is correlated with augmented transverse and sagittal skeletal expansion, while simultaneously inhibiting vertical growth trajectories.[14] Despite the acknowledged significance of masticatory musculature in craniofacial morphogenesis, the quantification of muscle thickness has been comparatively under-investigated relative to the extensive body of research dedicated to skeletal growth patterns. For example, a study by Park et al. (2018), utilizing USG, documented sexual dimorphism in masseter muscle thickness, with males exhibiting greater thickness than females, a finding that aligns with the observations reported in the present investigation.[15]

The findings presented in this study are substantiated by a corpus of existing research. For instance, Biondi et al. (2016) conducted an investigation into the interrelationship between masseter muscle size, maxillary intermolar width, and craniofacial vertical skeletal patterns.[16] Consistently, Kiliaridis et al. investigated the correlation between masseter muscle thickness and maxillary dental arch width.[17] These studies provide convergent evidence, lending further credence to the observations made herein. Conversely, their findings indicated a gender-specific correlation, wherein increased masseter muscle thickness was associated with wider dental arches exclusively in female participants, a result that diverges from the current study's observations. This inconsistency may stem from variations in developmental stages and demographic attributes between the respective study populations. Another research revealed a statistically significant positive linear correlation between masseter muscle thickness and maxillary dental arch width across both male and female subjects, thereby providing corroborative evidence for the conclusions drawn in the present study.[14]

Consistent with the current study, Rohila et al. (2012) demonstrated significant positive correlations between masseter muscle thickness and various craniofacial dimensions, including posterior facial height, symphysis width, intermolar width of maxillary first molars, and facial width.[18] Comparable results were reported by Parameswaran et al. (2010), who observed that increased masseter muscle thickness was associated with wider maxillary dental arches.[19] Furthermore, Sadeghian et al. (2009) identified masseter muscle thickness as a determinant factor influencing both maxillary dental arch width and mandibular intercanine arch width.[20] While these prior investigations primarily emphasized the role of muscle thickness, the present study extends these findings by underscoring the additional significance of the AP width of the masseter muscle in modulating dental arch morphology.

The initial sample size of 45 participants was determined through power analysis, employing a correlation coefficient (r) of 0.35, a significance level (α) of 0.05, and a statistical power of 0.84. Although this sample size was considered sufficient for the originally intended statistical analysis, it potentially lacked the power to detect effect sizes smaller than those anticipated. A subsequent recalculation of sample size indicates that a larger cohort, approximating 65 participants, would yield enhanced statistical power, thereby improving the reliability and generalizability of the study's conclusions. Given the inherent limitations of the sample size, the results of this investigation warrant a conservative interpretation, especially regarding their applicability to diverse populations. To validate these findings and elucidate the intricate associations between masseter muscle attributes and craniofacial dimensions, subsequent research employing larger cohorts is recommended. The manuscript consistently addresses the ramifications of the sample size constraint, thereby fostering transparency and contextualizing the study's inferences.

Research indicates that the buccolingual inclination of mandibular molars is modulated by masticatory muscle function, consequently impacting dental arch width.[21] Supporting this, Bishara et al. (1997) documented that male generally present with larger dental arch widths compared to females, a finding that aligns with the current study's observation of increased masseter muscle dimensions in male subjects.[22]

While the present study demonstrates compelling results, it is imperative to acknowledge its inherent limitations. Specifically, the utilization of USG, although a non-invasive and readily available modality, introduces significant operator dependency. Variations in image quality can arise from inconsistencies in probe pressure during acquisition and individual anatomical variations. Consequently, USG exhibits a higher degree of subjectivity and susceptibility to measurement errors when juxtaposed with advanced imaging techniques such as CT and MRI.[23–25]

Subsequent investigations should prioritize mitigating the identified limitations through the implementation of expanded sample sizes, the assessment of muscle elasticity, and the adoption of more objective imaging techniques. Furthermore, future research endeavors are warranted to elucidate the potential influence of developmental stages and ethnic diversity on the correlation between masseter muscle dimensions and dental arch morphology.

Conclusion

In summary, this research underscores the clinical relevance of masseter muscle dimensions in orthodontic treatment planning. The observed influence of substantial masticatory musculature on dental arch morphology and treatment efficacy highlights the potential for enhanced therapeutic protocols, especially for individuals predisposed to relapse or exhibiting malocclusion. Furthermore, USG is validated as a reliable and non-invasive modality for quantifying masseter muscle thickness, offering a safe and reproducible method for clinical assessment.

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