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Research Article/Özgün Araştırma

# Investigation of the masseter and temporalis muscles thicknesses in individuals with and without temporomandibular disorders by ultrasonography: A randomized controlled study

# Temporomandibular bozukluğu olan ve olmayan bireylerde masseter ve temporalis kas kalınlıklarının ultrasonografi ile incelenmesi: Randomize kontrollü bir çalışma

Halime ARIKAN[1], Seyit ÇITAKER[2], Sevilay BATIBAY[3], Cahit ÜÇOK[4], Zafer GÜNENDİ[5]

[1]Tokat Gaziosmanpaşa University, Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, 60250, Tokat-Turkey
[2]Gazi University, Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, 06490, Ankara-Turkey
[3]Göztepe Prof. Dr. Süleyman Yalçın City Hospital, 34722, İstanbul-Turkey
[4]Ankara University, Faculty of Dentistry, Department of Oral and Maxillofacial Surgery, 06560, Ankara-Turkey
[5]Gazi University, Faculty of Medicine, Department of Physical Therapy and Rehabilitation, Division of Rheumatology, 06560, Ankara-Turkey

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**Abstract**

**Aim:** The aim was to evaluate the impact of different temporomandibular disorder (TMD) diagnoses on the thickness of the masseter and temporalis muscles.

**Materials and Methods:** Individuals were divided into four groups: (1) myofascial pain; (2) disc displacements; (3) mixed group; and (4) asymptomatic control group. 53 individuals with TMD and 20 individuals without TMD were recruited.

**Results:** No significant differences were found among groups in masseter and temporalis muscles thickness at rest and maximum contraction ($p$>0.05). However, the masseter muscle thickness at rest and maximum contraction were greater in asymptomatic individuals than in individuals with TMD ($p$<0.05).

**Conclusion:** Masseter and temporalis muscles thickness are similar in the TMD subgroups and the asymptomatic control group at rest and maximum contraction.

**Keywords:** Masseter; Reliability; Temporalis; Temporomandibular disorders; Ultrasonography.

**Öz**

**Amaç:** Farklı temporomandibular bozukluk (TMB) tanılarının masseter ve temporalis kas kalınlıklarına etkisinin değerlendirilmesi amaçlandı.

**Gereç ve Yöntem:** Bireyler dört gruba ayrıldı: (1) miyofasiyal ağrı; (2) disk deplasmanları; (3) mikst grup; ve (4) sağlıklı grup. TMB'li 53 birey ve TMB'si olmayan 20 kişi çalışmaya alındı.

**Bulgular:** Gruplar arasında istirahatte ve maksimum kontraksiyonda masseter ve temporalis kaslarının kalınlığında anlamlı fark bulunmadı ($p$>0.05). Ancak istirahatte ve maksimum kontraksiyonda masseter kas kalınlığı sağlıklı bireylerde TMB'li bireylere göre daha fazlaydı ($p$<0.05).

**Sonuç:** Masseter ve temporalis kaslarının kalınlığı TMB alt gruplarında ve sağlıklı grupta istirahatte ve maksimum kontraksiyonda benzerdir.

**Anahtar Kelimeler:** Masseter; Güvenilirlik; Temporalis; Temporomandibular bozukluklar; Ultrasonografi.

**Yazışma Adresi/Address for Correspondence**: Halime ARIKAN, Tokat Gaziosmanpaşa University, Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, 60250, Tokat-Turkey, E-mail: halimearikan92@gmail.com

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## Introduction

Temporomandibular disorders (TMD) affect the stomatognathic system, which includes the chewing muscles and the component of temporomandibular joint (TMJ).[1–3] The causes of TMD are multifactorial and may result from dysregulation between neuromuscular, psychological, and anatomical conditions. Pain, joint noises, deviation and restriction in mandibular actions, and muscle and TMJ tenderness are among the symptoms of TMD. These situations also limit and/or negatively affect physiological activity.[4] Negative physiological activity may lead to changes in the muscles of the stomatognathic system, which are necessary to evaluate.

USG is a noninvasive, uncomplicated, cost-efficient method and easily applied.[5] Ultrasonography (USG) is a helpful technique in confirming structural muscle changes such as muscle contracture,[6,7] traumatization, overgrowth, and changes in surface soft tissue. USG is a reliable approach for evaluating neck and head muscles such as temporalis, masseter, digastric, and sternocleidomastoid muscles in individuals with TMD.[6] There has been reported evidence of increased muscle thickness in individuals with TMD. The use of USG in these individuals has significantly expanded, with numerous authors discovering new benefits for this technique. It has proven useful not only in myofascial pain but also in intra-articular derangements. Consequently, USG remains a promising technique for examining masticatory muscles.[5]

It has been suggested that USG can be employed to complement the clinical evaluation of patients with muscle-related temporomandibular disorders.[5] In oral myofascial pain, excessive or repeatable use may cause an overgrowth of the mastication muscles in the early phases, while in chronic cases, continuous pain may cause disuse atrophy. In this context, mastication muscle thickness is insightful as an objective measurement of oral motor function, which may vary in individuals with oral myofascial pain.[8] However, pain and impaired function in other TMD groups may induce changes in chewing muscle thickness.[5,6] In the literature, the masticatory muscle thicknesses were generally evaluated in asymptomatic individuals or individuals with TMD without classification.[5] Therefore, the aim of this study was to measure masseter and anterior temporalis muscle thicknesses at rest and maximum contraction in individuals with different diagnosis groups of TMD and in asymptomatic individuals. Thus, whether there is a difference between the masseter and temporalis muscle thicknesses of individuals with TMD (divided into subgroups) and asymptomatic individuals will be determined. It will be shown if there is a difference, especially in which group this difference is greater. Thus, to enhance the quality of TMJ movements, the emphasis will be on symmetrically strengthening the chewing muscles, among other factors.

## Materials and Methods

### Type of the study

This was a prospective and cross-sectional study.

### The sample size of the study

The study involved 73 individuals (14 males and 59 females; aged 24.81±6.80 years) aged between 18 and 60. Individuals who applied to Ankara University Faculty of Dentistry, Department of Oral and Maxillofacial Surgery, and were diagnosed with TMD by a specialist dentist were included in the study. Individuals were first referred to Gazi University, Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, and the physiotherapist questioned their demographic information. Then, accompanied by the same physiotherapist, he was taken to Gazi University Faculty of Medicine, Department of Physical Therapy and Rehabilitation, for USG evaluation by a specialist physician.

The a priori sample size of the study using the G*Power program, with a 95% confidence interval, 95% power, d= 0.80 effect size based on the large effect size (d=0.82) obtained from the reference study[9] was calculated as a total of 60 individuals that there were 15 individuals in each group. In the post-study sample size analysis, the effect size was d=0.80, based on

the strong effect size obtained from the masseter muscle thickness (d=0.72- 0.89) in the current study. The power of the study with a 5% error rate, 95% confidence interval, and 73 individuals was determined as more than 95%.

The sample group was selected by diagnosis and clinical examination according to inclusion/exclusion criteria. Individuals randomly divided into four groups according to the Diagnostic Criteria for TMD (DC/TMD):[10] (1) myofascial pain (group 1), (2) disc displacements (group 2), (3) mixed disorders (myofascial pain and disc displacements), (4) without TMD (control group). All participants were evaluated by a clinician calibrated with DC/TMD (fourth author). As an inclusion criterion, individuals in the TMD groups had at least one TMD diagnosis according to DC/TMD. Individuals with the diagnosis of myofascial pain, which is pain-related TMD, and disc displacement with reduction, which is intra-articular TMD, were determined by an oral and maxillofacial surgeon. Individuals showing the characteristics of these two diagnostic classes were grouped as mixed type. There were no signs or symptoms of TMD in the control group. Those who have a missing tooth or prosthesis, a history of trauma to the face, TMJ or cervical spine, a systemic or local disorder that may negatively affect the chewing system (e.g. fibromyalgia, neuralgia, myopathy, rheumatoid arthritis, oncological disease, joint laxity, and hypermobility), and any disease that may affect the muscular system and those who received medication or treatment were excluded from the study.[11] TMD that may develop secondary to the mentioned pathologies could hinder an objective discussion of the results. Perhaps more significant differences could arise in the presence of accompanying conditions and pathologies. Similarly, discussing the study might be challenging, as variations may occur in individuals who have undergone treatment.

**Data collection tools**

Masseter and anterior temporalis thicknesses were measured bilaterally with musculoskeletal USG and linear probe (Logiq 7 Pro; GE Yokogawa Medical System, Tokyo, Japan; 7.5–12 MHz), and the image was recorded directly on the screen with an accuracy of 0.1 mm. The masseter and anterior temporalis were identified by palpation. Individuals were asked to maintain the resting position (relaxed) and maximum contraction (biting) with maximum effort. The masseter muscle was measured at the midpoint between the zygomatic arch and the gonial angle. The anterior temporalis muscle was measured in front of the anterior border of the hairline. Measurements were taken from the muscular belly, where the muscle is thickest. During measurement, the gel was applied to the skin surface, and the transducer was operated until the optimized image was obtained. Individuals were given verbal instructions to perform the measurements efficiently (Figure 1).[11]

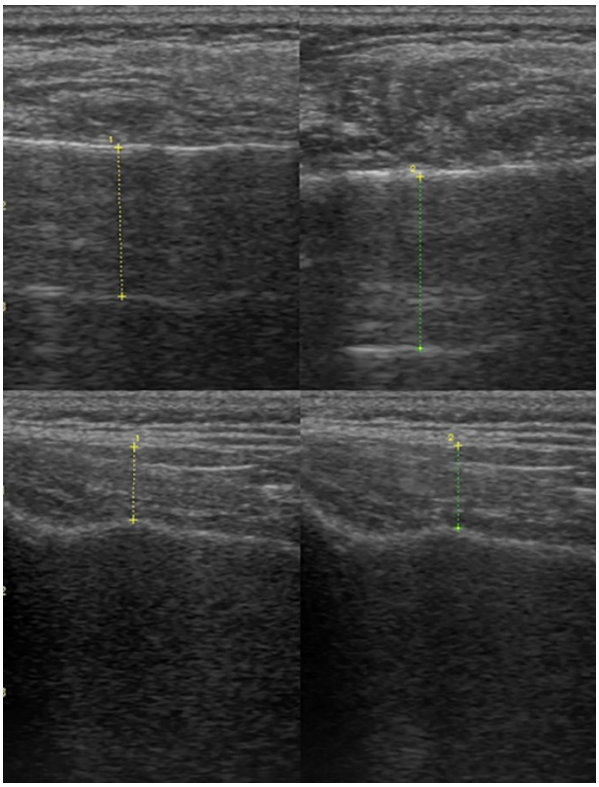


**Figure 1.** USG of the (above) masseter muscle at rest (left) and maximum contraction (right), and the (below) temporalis muscle (anterior part) at rest (left) and maximum contraction (right)

Two measurements (test-retest) were performed on the same day to determine rater reliability and to ensure that muscle-related factors had not changed. Individuals sat in a chair with their arms at their sides. The head and neck were in a neutral position. Thickness for each muscle was measured by randomly selecting the order of measurement.

The average of these two measurements was used for the analyses.[6] However, in order to prove the adequacy of a single measurement performed by a specialist physician, the intraexaminer reliability of two measurements of a single evaluator was tested.

## Data analysis

Statistical analyses were performed with SPSS 22.0 software (Statistical Package for Social Sciences, IBM, Chicago, IL, USA). Normal distribution was investigated using the Kolmogorov-Smirnov test. Descriptive values are given as mean±standard deviation and median (minimum-maximum). Multiple group comparisons (myofascial pain/disc displacements/mixed group/asymptomatic control) were made with One-Way Analysis of Variance (ANOVA) for parametric data and Kruskal-Wallis Analysis of Variance for nonparametric data. Homogeneity of variances was evaluated with the Levene test. The difference between the two independent groups (TMD/asymptomatic control) was determined by Independent Sample t-test.

Relative reliability (Intraclass Correlation Coefficient (ICC)), absolute reliability (standard error of measurement (SEM)), and minimum detectable change (MDC) were analyzed. Intraexaminer (test-retest) reliability was evaluated using $ICC_{(2,1)}$.[12,13] ICC values between 0.81-1.00, 0.61-0.80, 0.41-0.60, 0.21-0.40 and 0.00-0.20 indicate excellent, good, moderate, fair and poor reliability, respectively.[14] SEM and MDC with 95% confidence intervals were determined according to the following formulas:

$SEM_{95}$: $Sp^* \sqrt{1 - ICC}$,[13] Sp: Pooled standard deviations of test-retest trials

$MDC_{95}$: $z * SEM * \sqrt{2}$,[13] z = 1.96 (based on 95% confidence) and SEM is the standard error of measurement

Agreement and systematic deviation between intraexaminer measurements were examined (t-test and Bland Altman plots).

*p*-values of less than 0.05 were considered as a statistically significant result.

## Ethics Committee Approval

Permission was received from the Tokat Gaziosmanpaşa University Clinical Research Ethics Committee to conduct the research (decision no: 83116987-399 and decision date: 9 June 2022). Additionally, the research was entered at ClinicalTrials.gov (NCT04277052). The study was in compliance with the Helsinki Declaration.

## Results

Demographic information of individuals divided according to diagnosis groups was shown in Table 1. Age, weight, height, body mass index, and duration of complaints of individuals in different groups were similar (Table 1). There was no disproportionality or difference in gender distribution between groups. The myofascial pain group consisted of 15 women and 3 men, the disc displacement group had 15 women and 3 men, and the mixed group included 15 women and 2 men. The asymptomatic control group comprised 14 women and 6 men.

**Table 1.** Demographic characteristics of individuals.

| | **Myofascial pain group (n=18)** | **Disc displacements group (n=18)** | **Mixed group (n=17)** | **Asymptomatic control group (n=20)** | **Total (n=73)** | ***p*** |
|---|---|---|---|---|---|---|
| | Mean±SD | Mean±SD | Mean±SD | Mean±SD | Mean±SD | |
| **Age (years)** | 24.50±5.94 | 25.50±10.11 | 23.71±4.38 | 25.40±5.85 | 24.81±6.80 | 0.412$^{\alpha}$ |
| **Weight (kg)** | 59.06±10.91 | 60.91±10.28 | 61.41±9.93 | 66.40±11.51 | 62.05±10.86 | 0.184$^{\beta}$ |
| **Height (m)** | 1.65±0.07 | 1.65±0.78 | 1.67±0.06 | 1.69±0.11 | 1.67±0.08 | 0.263$^{\beta}$ |
| **BMI ($kg/m^2$)** | 21.60±3.20 | 22.45±3.27 | 21.89±3.11 | 23.10±2.62 | 22.29±3.04 | 0.451$^{\beta}$ |
| **Complaint duration (months)** | 64.06±42.90 | 41.78±28.40 | 44.47±31.44 | - | 47.21±35.66 | 0.134$^{\alpha}$ |

kg: Kilogram; m: Meter; Med: Median; min: Minimum; max: Maximum; α: Kruskal-Wallis Analysis of Variance; β: One-Way Analysis of Variance

Right and left masseter and temporalis muscle thicknesses were similar in asymptomatic individuals and individuals with TMD (all and with different diagnoses) at rest and contraction (Table 2). Right and left masseter muscle thicknesses were higher in asymptomatic individuals than in individuals with TMD (all) at rest and in contraction (Table 3).

**Table 2.** Comparison of muscle thicknesses of the groups at rest and maximum contraction.

| (mm) | Myofascial pain group (n=18) | Disc displacements group (n=18) | Mixed group (n=17) | Asymptomatic control group (n=20) | *p* |
|---|---|---|---|---|---|
| | Mean±SD | Mean±SD | Mean±SD | Mean±SD | |
| **RM (R)** | 15.15±2.69 | 15.61±3.61 | 16.43±3.27 | 17.26±2.15 | 0.143$^{\beta}$ |
| **LM (R)** | 14.76±2.76 | 15.61±3.48 | 16.40±2.96 | 17.09±1.74 | 0.070$^{\beta}$ |
| **RM (MC)** | 17.11±2.93 | 17.73±3.82 | 18.71±3.57 | 19.40±1.99 | 0.123$^{\beta}$ |
| **LM (MC)** | 16.75±2.98 | 17.84±3.59 | 18.53±3.17 | 19.06±1.54 | 0.093$^{\beta}$ |
| **RT (R)** | 7.41±0.87 | 7.65±1.38 | 7.71±1.00 | 7.70±0.72 | 0.804$^{\beta}$ |
| **LT (R)** | 7.30±1.21 | 7.48±1.42 | 7.49±1.01 | 7.46±0.56 | 0.950$^{\beta}$ |
| **RT (MC)** | 8.20±0.79 | 8.62±1.55 | 8.50±1.08 | 8.66±0.59 | 0.551$^{\beta}$ |
| **LT (MC)** | 8.28±1.09 | 8.45±1.56 | 8.52±1.05 | 8.40±0.58 | 0.934$^{\beta}$ |

mm: Millimeter; RM: Right masseter; LM: Left masseter; RT: Right temporalis; LT: Left temporalis; R: Rest; MC: Maximum contraction; Med: Median; min: Minimum; max: Maximum; β: One-Way Analysis of Variance

**Table 3.** Comparison of muscle thicknesses of individuals with and without TMD.

| (mm) | TMD group (n=53) | Asymptomatic control group (n=20) | *p* |
|---|---|---|---|
| | Mean±SD | Mean±SD | |
| **RM (R)** | 15.72±3.20 | 17.26±2.15 | **0.050$^{\mu}$** |
| **LM (R)** | 15.58±3.10 | 17.09±1.74 | **0.043$^{\mu}$** |
| **RM (MC)** | 17.83±3.45 | 19.40±1.99 | **0.019$^{\mu}$** |
| **LM (MC)** | 17.69±3.28 | 19.06±1.54 | **0.019$^{\mu}$** |
| **RT (R)** | 7.59±1.09 | 7.70±0.72 | 0.682$^{\mu}$ |
| **LT (R)** | 7.42±1.21 | 7.46±0.56 | 0.875$^{\mu}$ |
| **RT (MC)** | 8.44±1.17 | 8.66±0.59 | 0.294$^{\mu}$ |
| **LT (MC)** | 8.41±1.24 | 8.40±0.58 | 0.964$^{\mu}$ |

mm: Millimeter; RM: Right masseter; LM: Left masseter; RT: Right temporalis; LT: Left temporalis; R: Rest; MC: Maximum contraction; Med: Median; min: Minimum; max: Maximum; μ: Independent Samples t-Test

The first and second measurement values of right and left masseter and temporalis muscle thicknesses of asymptomatic individuals and individuals with TMD (all and with different diagnoses) at rest and in contraction are given in Table 4.

**Table 4.** Descriptive values for muscle thicknesses of TMD subgroups, all individuals with TMD, asymptomatic individuals, and all individuals.

| (mm) | Myofascial pain group (n=18) | Disc displacements group (n=18) | Mixed group (n=17) | Asymptomatic control group (n=20) | TMD group (n=53) | Total (n=73) |
|---|---|---|---|---|---|---|
| | Mean±SD | Mean±SD | Mean±SD | Mean±SD | Mean±SD | Mean±SD |
| **RM-1 (R)** | 15.12±2.53 | 15.58±3.53 | 16.34±3.20 | 17.13±2.21 | 15.67±3.09 | 16.07±2.94 |
| **RM-2 (R)** | 15.17±2.96 | 15.64±3.74 | 16.52±3.39 | 17.38±2.12 | 15.76±3.36 | 16.21±3.14 |
| **LM-1 (R)** | 14.62±2.89 | 15.57±3.44 | 16.43±2.92 | 17.18±1.80 | 15.52±3.13 | 15.98±2.91 |
| **LM-2 (R)** | 14.90±2.69 | 15.66±3.59 | 16.37±3.08 | 17.00±1.77 | 15.63±3.14 | 16.00±2.89 |
| **RM-1 (MC)** | 16.99±3.12 | 17.68±3.65 | 18.55±3.50 | 19.39±2.04 | 17.72±3.42 | 18.18±3.18 |
| **RM-2 (MC)** | 17.23±2.86 | 17.77±4.02 | 18.86±3.68 | 19.41±2.01 | 17.94±3.55 | 18.34±3.25 |
| **LM-1 (MC)** | 16.57±3.20 | 17.80±3.56 | 18.18±3.22 | 19.04±1.53 | 17.50±3.34 | 17.93±3.02 |
| **LM-2 (MC)** | 16.92±2.80 | 17.87±3.68 | 18.89±3.26 | 19.07±1.64 | 17.88±3.30 | 18.20±2.98 |
| **RT-1 (R)** | 7.31±0.84 | 7.68±1.41 | 7.67±1.07 | 7.73±0.77 | 7.55±1.12 | 7.60±1.04 |
| **RT-2 (R)** | 7.52±0.98 | 7.62±1.39 | 7.75±1.06 | 7.66±0.79 | 7.63±1.14 | 7.64±1.05 |
| **LT-1 (R)** | 7.36±1.15 | 7.40±1.58 | 7.38±1.01 | 7.39±0.69 | 7.38±1.25 | 7.38±1.12 |
| **LT-2 (R)** | 7.25±1.33 | 7.57±1.35 | 7.59±1.13 | 7.52±0.60 | 7.46±1.26 | 7.48±1.12 |
| **RT-1 (MC)** | 8.24±0.80 | 8.57±1.60 | 8.52±1.30 | 8.71±0.75 | 8.44±1.26 | 8.51±1.14 |
| **RT-2 (MC)** | 8.17±0.92 | 8.67±1.59 | 8.49±0.95 | 8.61±0.63 | 8.44±1.19 | 8.49±1.07 |
| **LT-1 (MC)** | 8.30±1.15 | 8.42±1.67 | 8.58±1.13 | 8.33±0.68 | 8.43±1.32 | 8.41±1.18 |
| **LT-2 (MC)** | 8.26±1.19 | 8.47±1.50 | 8.45±1.13 | 8.48±0.70 | 8.39±1.26 | 8.42±1.13 |

mm: Millimeter; RM: Right masseter; LM: Left masseter; RT: Right temporalis; LT: Left temporalis; R: Rest; MC: Maximum contraction

The intraexaminer ICC values of right and left masseter and temporalis muscle thicknesses of asymptomatic individuals and individuals with TMD (all and with different diagnoses) at rest and in contraction ranged from 0.401-0.980. The ICC values of the USG measurements ranged from moderate to excellent (Table 5).

**Table 5.** Intraclass correlation coefficients (ICC) (confidence intervals of 95%) for two measurements (test-retest).

| | Myofascial pain (n=18) | Disc displacements (n=18) | Mixed (n=17) | Asymptomatic control (n=20) | TMD (n=53) | Total (n=73) |
|---|---|---|---|---|---|---|
| **RM (R)** | 0.912 | 0.980 | 0.970 | 0.952 | 0.960 | 0.960 |
| **LM (R)** | 0.947 | 0.961 | 0.943 | 0.899 | 0.952 | 0.949 |
| **RM (MC)** | 0.912 | 0.978 | 0.969 | 0.925 | 0.959 | 0.957 |
| **LM (MC)** | 0.958 | 0.970 | 0.890 | 0.901 | 0.942 | 0.941 |
| **RT (R)** | 0.802 | 0.945 | 0.771 | 0.720 | 0.863 | 0.840 |
| **LT (R)** | 0.898 | 0.856 | 0.766 | 0.514 | 0.844 | 0.813 |
| **RT (MC)** | 0.666 | 0.899 | 0.801 | 0.479 | 0.832 | 0.795 |
| **LT (MC)** | 0.754 | 0.932 | 0.736 | 0.401 | 0.834 | 0.790 |

RM: Right masseter; LM: Left masseter; RT: Right temporalis; LT: Left temporalis; R: Rest; MC: Maximum contraction

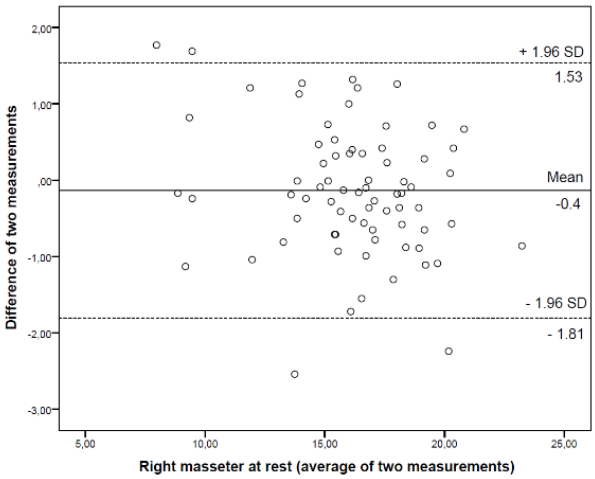
The SEM and MDC values of right and left masseter and temporalis muscle thicknesses of asymptomatic individuals and individuals with TMD (all and with different diagnoses) at rest and in contraction ranged from 0.335-0.988 and 0.929-2.481, respectively (Table 6).

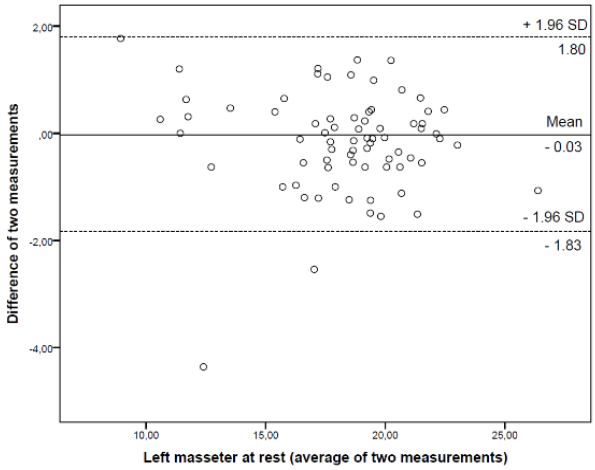
**Table 6.** The standard error of measurement (SEM) and minimal detectable change (MDC) of muscle thicknesses.

| | Myofascial pain group (n=18) | | Disc displacements group (n=18) | | Mixed group (n=17) | | Asymptomatic control group (n=20) | | TMD (n=53) | | Total (n=73) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **SEM** | **MDC** | **SEM** | **MDC** | **SEM** | **MDC** | **SEM** | **MDC** | **SEM** | **MDC** | **SEM** | **MDC** |
| **RM (R)** | 0.838 | 2.323 | 0.529 | 1.466 | 0.573 | 1.588 | 0.454 | 1.258 | 0.651 | 1.805 | 0.603 | 1.671 |
| **LM (R)** | 0.629 | 1.744 | 0.711 | 1.971 | 0.736 | 2.040 | 0.568 | 1.574 | 0.686 | 1.902 | 0.659 | 1.827 |
| **RM (MC)** | 0.895 | 2.481 | 0.581 | 1.611 | 0.610 | 1.691 | 0.569 | 1.577 | 0.700 | 1.940 | 0.666 | 1.846 |
| **LM (MC)** | 0.585 | 1.622 | 0.640 | 1.774 | 0.988 | 2.739 | 0.510 | 1.414 | 0.762 | 2.112 | 0.707 | 1.960 |
| **RT (R)** | 0.391 | 1.084 | 0.335 | 0.929 | 0.518 | 1.436 | 0.418 | 1.159 | 0.420 | 1.164 | 0.418 | 1.159 |
| **LT (R)** | 0.403 | 1.117 | 0.562 | 1.558 | 0.516 | 1.430 | 0.452 | 1.253 | 0.498 | 1.380 | 0.483 | 1.339 |
| **RT (MC)** | 0.507 | 1.405 | 0.514 | 1.425 | 0.519 | 1.439 | 0.501 | 1.389 | 0.506 | 1.403 | 0.502 | 1.392 |
| **LT (MC)** | 0.591 | 1.638 | 0.425 | 1.178 | 0.587 | 1.627 | 0.537 | 1.489 | 0.531 | 1.472 | 0.532 | 1.475 |

RM: Right masseter; LM: Left masseter; RT: Right temporalis; LT: Left temporalis; R: Rest; MC: Maximum contraction

Bland-Altman plots (Figure 2) show the reliability of the measurements in terms of systematic error and random error. Systematic error was significantly smaller for all scores (Figure 2).



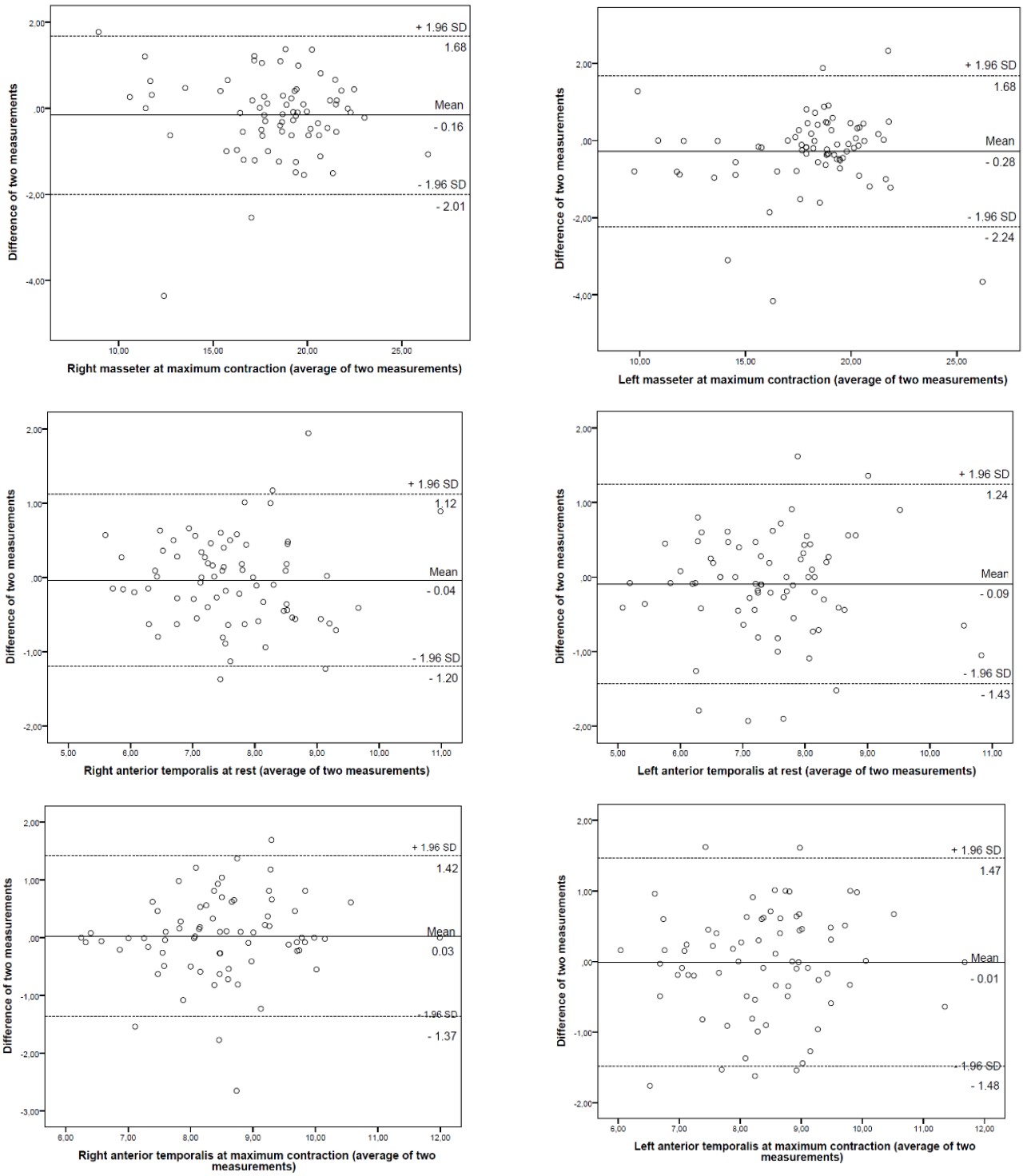



**Figure 2.** Bland–Altman plots of the masseter and temporalis muscles thicknesses intraexaminer scores. The central line represents the mean differences between the first and second measurements; the upper and lower dotted lines represent the upper and lower 95% limits of agreement (mean differences ± 1.96 SD of the differences), respectively.

## Discussion

It was the main purpose of the study to draw attention to state that masticatory muscle thicknesses would not differ between different diagnostic groups of TMD. Because it was thought that function and biomechanics could be adversely affected by the presence and severity of symptoms in all individuals with TMD. While there was a significant difference in masseter muscle thickness between individuals with TMD and asymptomatic participants, the temporalis muscle thickness, although not significantly different, was observed to be thicker in the asymptomatic control group. Additionally, masticatory muscle thickness showed similarity between individuals with various TMD diagnostic

groups and asymptomatic individuals. It is possible that changes in muscle thickness may have occurred within the TMD subgroups, but these may not have made a difference. However, when asymptomatic individuals and all TMD individuals were compared, it was thought that these changes might have been more. According to the results of the current study, the similarity of masseter and temporalis muscle thicknesses at rest and contraction between the subgroups of TMD and the asymptomatic control group was a suggestive result. No difference was expected between the TMD subgroups as per the hypothesis of the study. However, the lack of difference with the asymptomatic control group showed that asymptomatic individuals should also be questioned and informed in terms of parafunctional habits such as clenching and/or grinding teeth, biting nails and/or lips, biting pencils and/or straws. Although asymptomatic individuals were asymptomatic and without TMD, it was inferred to consider that they could potentially tend to TMD. When all TMD and asymptomatic individuals were compared, the fact that masseter muscle thicknesses were greater at rest and contraction in favor of asymptomatic individuals may be due to the fact that the masseter is a strong masticatory muscle. Because of the functional and biomechanical changes that occur with TMD, a correct contraction and relaxation may not happen. This also showed its effect on thickness, which is one of the muscle strength parameters. Since the anterior temporalis is mostly responsible for pulling the mandible up vertically, its thickness was thought to be similar in TMD and asymptomatic control groups. Another point to be noted was that a single measurement of masticatory muscle thickness by an experienced evaluator was reliable and sufficient.

In a study comparing the masseter muscle thicknesses of bruxist and nonbruxist individuals, muscle thickness at rest was similar, while muscle thickness at contraction was greater in the bruxist group.[15] In another study conducted in individuals with and without bruxism, the masseter muscle thickness of individuals with bruxism was greater than in individuals without bruxism.[16] In a study examining myofascial pain, click and control groups, masseter muscle thickness was higher in the control group.[17] The sternocleidomastoid and masseter muscle thicknesses were examined in TMD and asymptomatic control groups, and it was noted that the masseter muscle thickness was higher in the asymptomatic control group at rest and during contraction.[18] In a study conducted in 2022, the masseter muscle thickness of asymptomatic individuals with myofascial pain was examined. Muscle thickness at rest was higher in the group with myofascial pain, while muscle thicknesses at contraction were similar.[19] Considering the literature, it is seen that there are different results[15,16,19] as well as similar results[17,18] with the current study. In the present study, masseter and anterior temporalis thicknesses were compared between myofascial pain, disc displacements, and mixed and asymptomatic control groups. The reasons for the differences in muscle thickness between the studies were the diet, jaw structure, the individuals forming the study groups (female, male or female-male), and the diagnosis groups (TMD-healthy, MPD-click-control, mixed-articular, bruxist-non-bruxist), etc. may cause. It was observed that temporalis muscle thickness was not examined frequently in studies. In addition, diagnostic classes were not systematic and detailed. When the studies evaluating the masticatory muscle thickness of only asymptomatic individuals[8,20,21] and only individuals with TMD[22,23] were examined, muscle thicknesses were less than the current study. Different nutritional habits and parafunctional habits were thought to be effective in this.

Studies examining the reliability of measurement of masseter and temporalis muscle thickness by USG showed that intraexaminer ICC values varied from good to excellent.[8,16,21] In one of these studies performed on asymptomatic individuals, intraexaminer ICC values of masseter muscle thickness were found to be between 0.69-0.88, and intraexaminer ICC values of temporalis muscle thickness were found to be between 0.70-0.79. In the same study, intraexaminer SEM and MDC values varied between 0.31-1.49 and 0.85-4.13, respectively.[8] In another

study examining masseter muscle thickness in asymptomatic individuals, the intraexaminer ICC value was recorded as 0.959.[21] In the study examining masseter muscle thickness in bruxism and asymptomatic individuals, intraexaminer ICC values were 0.79 and 0.84, respectively. In the same study, SEM and MDC values were 0.40, respectively; 0.15 and 1.11; 0.42.[16] In the current study, intraexaminer reliability at rest and maximum contraction was examined in both individuals with TMD and asymptomatic controls. In addition, individuals with TMD were analyzed by dividing them into subgroups. The results of the study showed that the measurement of masseter thickness at rest and at maximum contraction was excellent in all groups. For the measurement of temporalis thickness, it was also from moderate to excellent. In addition, in this study, to evaluate the absolute reliability and to define the amount of change in a variable SEM and MDC values were also calculated. These two measurements are important parameters of reliability. SEM and MDC outcomes supported the intraexaminer reliability of USG evaluation of masseter and temporalis muscle thicknesses at rest and maximum contraction in all groups. According to this study, a single measurement by an experienced examiner is sufficient and reliable for an accurate result. Thus, time and cost savings can be achieved. To evaluate the agreement and systematic variation between the measurements performed Bland Altman plots also proved the reliability of the USG method. Although there were some slight differences between the measures, the outcome measures were consistent with the intervals of agreement. However, one point should be mentioned. Reliability analyzes were high for measurements of muscle thickness in individuals with TMD. It was also high for the measurement of masseter muscle thickness of asymptomatic individuals. Interestingly, the ICC values of the anterior temporalis muscle were slightly lower, especially at maximum contraction in asymptomatic individuals. Although this was clearly not understood as the reason, some participants may not have been able to rest and maximum contraction simultaneously with the commands. Because high ICC values were obtained even in individuals with TMD, low ICC values of only temporalis muscle thickness in asymptomatic individuals, especially at maximum contraction period, made to the authors think of this.

## Limitations

The limitation of this study was that it did not evaluate interexaminer reliability. This limitation occurred because there was no other investigator experienced in the evaluation of masticatory muscles with the USG. Subsequent research could explore interexaminer reliability and investigate individuals with arthritis or arthrosis in the TMJ. All masticatory and neck muscles can be examined, not limited to masseter and anterior temporalis muscle thicknesses. Additionally, there is a need for studies with large and equal sample sizes that concurrently examine both asymptomatic individuals and subgroups with TMD.

## Conclusion

In conclusion to the knowledge of authors, this was the first study to investigate comprehensively masseter and temporalis muscle thickness and intraexaminer reliability among TMD subgroups and asymptomatic control. In contrast to studies emphasizing that individuals with myofascial pain disorder experience greater changes in masticatory muscle thickness, changes may occur in all groups of TMD especially in the masseter muscle. It was observed that the masseter muscle thickness was significantly higher in the asymptomatic asymptomatic control group. The same trend was noted for the temporalis muscle, although the difference was not statistically significant. This suggests that muscles exhibiting a healthy contraction-relaxation pattern may display greater thickness. Clinically, there has been an emphasis on the significance of concentrating on symmetrical muscle strength. Disruption of muscle symmetry and biomechanics may occur not only in myofascial pain but also in intra-articular disorders. Consequently, this consideration should be taken into account at every stage of rehabilitation.

## Ethics Committee Approval

Permission was received from the Tokat Gaziosmanpaşa University Clinical Research Ethics Committee to conduct the research (decision no: 83116987-399 and decision date: 9 June 2022). Additionally, the research was entered at ClinicalTrials.gov (NCT04277052). The study was in compliance with the Helsinki Declaration.

## Informed Consent

Verbal permission and written informed consent forms were obtained from volunteers to participate in the study.

## Author Contributions

Study concept/design: HA., SÇ., CÜ., ZG. Data collecting: HA., SB. Data analysis and interpretation: HA., SÇ. Literature review, writers: HA., SÇ., SB., CÜ., ZG. The final version of this article was read and approved by all authors.

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## Conflict of Interest

There is no conflict of interest regarding the research.

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## Peer-review

Externally peer-reviewed.

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