



# Evaluation of the thickness of masticatory muscles in patients with chronic periodontitis by ultrasonography

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## Abstract

**Objectives** Periodontitis is one of the most common chronic inflammatory diseases. It causes changes in the biting abilities of individuals. However, periodontal treatment has positive effects on masticatory function. The aim of this study is to determine the effect of periodontitis and periodontal treatment on masticatory abilities by measuring masseter and temporal muscle thicknesses with ultrasonography before and after periodontal treatment in chronic periodontitis patients.

**Methods** The patients included in the study were determined by clinical and radiological examination. The thickness of the masseter and temporal muscles of the patients were measured by ultrasonography. Periodontal measurements and treatments of the patients were completed by a single physician. IBM SPSS 20.0 (IBM Corp., Armonk, NY) statistical program was used for statistical analysis.

**Results** A statistically significant difference was found between the values of periodontal measurements before and after treatment ( $p < 0.05$ ). In the ultrasonography measurements of the thickness of masseter and anterior temporal muscles, a statistically significant increase was observed in both rest and contraction values at all time intervals ( $p < 0.05$ ). Muscle thicknesses of male patients were higher than female patients.

**Conclusions** Periodontitis negatively affects the masticatory performance of individuals. Chronic periodontitis patients should be referred for periodontal treatment without wasting time.

**Keywords** Ultrasonography · Masseter muscle · Temporal muscle · Periodontitis · Periodontal treatment

## 1 Introduction

The masticatory system consists of teeth, joints, muscles and bones and is responsible for speaking, chewing, tasting, swallowing and breathing. This system is regulated by a complex neurological control mechanism [1]. A problem that may occur in any of these units causes the entire system to be affected.

Periodontitis is one of the most common chronic diseases worldwide. It is an inflammatory disease characterized by the destruction of tooth-supporting tissues [2]. Periodontitis causes changes in the biting abilities of individuals. In

addition, the loss of tooth-supporting tissues impairs the sensory function of periodontal tissues, and chewing dysfunctions may develop as a result [3]. There are various studies in the literature investigating the effect of periodontitis on masticatory muscles and biting abilities [3–5]. It has also been reported that periodontal treatment has positive effects on masticatory function [6].

Masticatory muscles can be examined using imaging techniques such as ultrasonography (USG), magnetic resonance imaging (MRI) and computed tomography (CT) [7]. The use of USG in dentistry is becoming more common due to its advantages such as containing no ionizing radiation, being non-invasive, easy to apply, and being easily tolerated by patients [8]. In addition, USG is accepted as a reliable method for examining the muscles that are important for mastication, such as masseter and temporal muscles [9].

The aim of this study is to determine the effect of periodontitis and periodontal treatment on masticatory performance by measuring masseter and temporal muscle

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thicknesses with USG before and after periodontal treatment in chronic periodontitis patients.

## Materials and methods

This study received approval from the Ethics Committee of Çukurova University Faculty of Medicine and was conducted in adherence to the Helsinki Declaration of 1975, as revised in 2013. (date: 05.11.2021, meeting no: 116, decision no: 71).

### Study group

32 patients (18 females 14 males, aged between 35 and 40 years, mean age 37.1 years) who applied to the Faculty of Dentistry for dental examination were included in this study. After clinical and radiological examination, all individuals who met the inclusion criteria were informed about the present study. Muscle thickness measurements with USG and periodontal treatment process were started after the participants who agreed to participate in the study signed the informed consent form.

The inclusion criteria were determined as follows:

- Having chronic periodontitis
- Presence of at least four occlusal units in the posterior teeth (a pair of premolars in occlusion was counted as one unit, and a pair of molars in occlusion was counted as two units) [10]

The exclusion criteria were determined as follows:

- Having any systemic disease
- Using any type of drug
- Having less than 20 teeth
- Having prosthetic restoration (Single crowns, fixed dental prostheses, removable dental prostheses)
- Having implant restoration
- Have had periodontal treatment in the last one year
- Having a painful tooth (pulpitis)
- Pregnancy
- Smoking

### Periodontal procedure

The diagnosis of chronic periodontitis was made according to the following criteria: radiographically observed bone loss, presence of bleeding on probing and presence of pockets of 5 mm or more in at least six teeth [5].

Clinical attachment loss (CAL), probing pocket depth (PD), plaque index (PI) and gingival index (GI) were recorded by a physician from six sites (mesiobuccal,

midbuccal, distobuccal, mesiolingual, midlingual, distolingual) for each tooth. A periodontal probe (UNC-15, Hu-Friedy, USA) was used for measurements. The mean values of each patient's measurements were used for statistical analysis [10]. Measurements were repeated at 6 months after periodontal treatment.

Periodontal treatment (scaling-root planing, oral hygiene instructions and occlusal adjustment if needed) was initiated immediately after clinical periodontal measurements. USG measurements of the patients, and all mechanical treatment was completed in the same session. For consistency, all patients were treated by a single physician.

### USG procedure

Masseter and anterior temporal muscle thicknesses were measured bilaterally using a high-frequency linear scanning probe (7 MHz) in the B-mode of the Clarius Mobile Health (Vancouver, Canada) ultrasound device.

During imaging, patients were positioned in a sitting position with the Frankfurt horizontal plane parallel to the floor. The probe was placed perpendicular to the skin to avoid artifacts. The air between the probe and the skin was prevented by using a water-based gel.

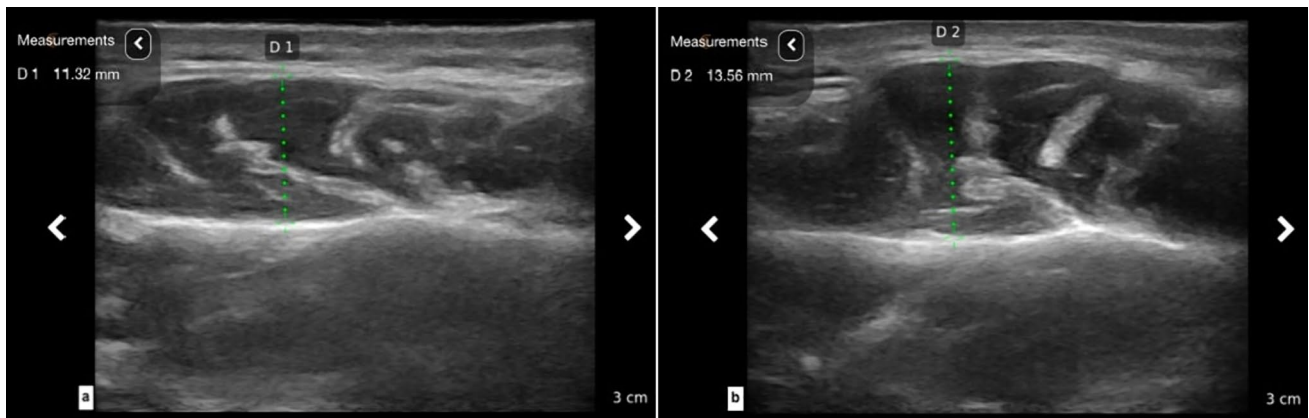
Masseter muscle imaging was performed from the thickest part of the muscle on palpation, in the middle of the zygomatic arch and the gonial angle [11]. Anterior temporal muscle imaging was performed in front of the anterior border of the hairline [12]. Images were acquired for both the right and left sides with the muscles at rest and in the maximum intercuspal position.

Masseter and temporal muscle thickness measurements were made on the screen at the same time, with the help of the distance measurement feature of the USG device, over images of the muscles at rest and maximum contraction (Figs. 1 and 2).

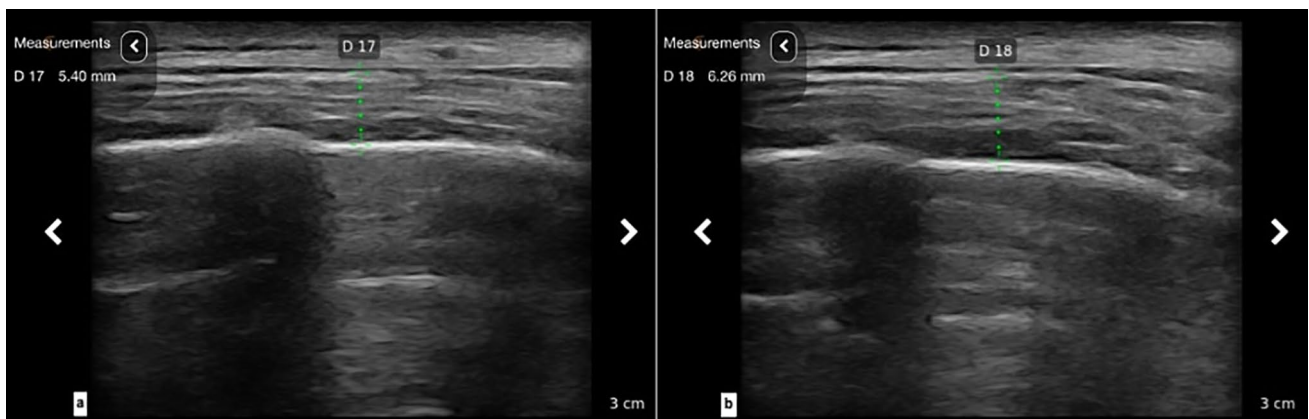
Measurements were made by the same oral and maxillofacial radiologist three times at 5-min intervals. The mean value of three measurements was used for statistical analysis. At 3 months and 6 months after the first measurement, the second and third measurements were completed in the same way as the first measurement.

### Statistical analysis

IBM SPSS 20.0 (IBM Corp., Armonk, NY) statistical program was used for statistical analysis. The significance level was determined as  $p < 0.05$ . Data are summarized as mean  $\pm$  standard deviation, median(minimum–maximum), or frequency (%). The conformity of the variables to the normal distribution was evaluated with the Shapiro–Wilks test ( $n < 50$ ) or the Kolmogorov–Smirnova ( $n \geq 50$ ) test.



**Fig. 1** Measurement of the thickness of the masseter muscle. **a** Rest. **b** Contraction



**Fig. 2** Measurement of the thickness of the temporal muscle. **a** Rest. **b** Contraction

Determination of the sample size was made using the G\*Power 3.1 program. To our knowledge, there was no study with a similar design in the literature. Repeated Measures Analysis of Variance (within factors) was chosen as a statistical test. Total sample size was calculated as 28 (effect size = 0.25,  $\alpha = 0.05$ ,  $\beta = 0.80$ , number of repetitions = 3). Since it is a follow-up study, the final sample size for the groups was determined as 32 in order to prevent data loss.

According to the independent bivariate parameters examined, the data were compared using the independent sample t-test or the Mann–Whitney U test (if the data were normally distributed and not normally distributed, respectively). The data were compared according to the dependent bivariate parameters examined using the dependent sample t-test or the Wilcoxon sign-rank test (if the data were normally distributed and not normally distributed, respectively).

Repeated measurements ANOVA analysis was used to examine the time-dependent changes in muscle thickness measurements. In addition to time-dependent changes in muscle thickness measurements, gender and age interactions

were also examined. Bonferroni posthoc test was applied for pairwise comparisons of time-dependent changes.

Intra-class correlation coefficient (ICC) was evaluated to determine the intraobserver reliability in muscle thickness measurements.

## Results

This study was conducted with a total of 32 patients aged between 35 and 40 (mean age: 37.1), 18 female (56.25%) and 14 male (43.75%).

In terms of periodontal measurements, a statistically significant difference was found between the values before and after treatment ( $p < 0.05$ ) (Table 1).

The intra-class correlation coefficient (ICC) was evaluated to determine the intra-observer reliability for USG measurements. All ICCs were greater than 0.95 and excellent agreement was observed ( $p < 0.001$ ). The mean value of three measurements was used for statistical analysis.

**Table 1** Time-dependent changes in periodontal measurements

	N	Mean ± SD	Median (Min–Max)	p
<b>Probing pocket depth</b>				
Before treatment	32	2.95 ± 0.73	2.89(1.9–4.15)	< 0.001 <sup>a</sup>
After treatment	32	2.14 ± 0.8	1.83(1.41–3.74)	
<b>Clinical attachment loss</b>				
Before treatment	32	3.2 ± 0.66	3.09(2.27–4.32)	< 0.001 <sup>a</sup>
After treatment	32	2.29 ± 0.75	2.01(1.56–3.78)	
<b>Gingival index</b>				
Before treatment	32	2.3 ± 0.14	2.35(2.01–2.47)	< 0.001 <sup>a</sup>
After treatment	32	0.57 ± 0.14	0.6(0.33–0.94)	
<b>Plaque index</b>				
Before treatment	32	2.38 ± 0.12	2.4(2.12–2.6)	< 0.001 <sup>b</sup>
After Treatment	32	1.17 ± 0.13	1.16(0.81–1.37)	

Data are summarized as mean ± standard deviation, median (minimum–maximum)

<sup>a</sup>Wilcoxon sign rank test

<sup>b</sup>Dependent sample *t*-test

**Table 2** Time-dependent changes of the mean values of the thickness of the masseter and temporal muscles

	N	Baseline	3. Month	6. Month	p <sup>a</sup>
<b>Masseter rest</b>					
	32	9.56 ± 1.35 <sup>φ,ψ</sup>	10.47 ± 1.19 <sup>ψ</sup>	11.09 ± 1.29	< 0.001
<b>Masseter contraction</b>					
	32	11.97 ± 1.78 <sup>φ,ψ</sup>	12.87 ± 1.58 <sup>ψ</sup>	13.39 ± 1.56	< 0.001
<b>Temporal rest</b>					
	32	4.85 ± 0.76 <sup>φ,ψ</sup>	5.54 ± 0.9 <sup>ψ</sup>	5.76 ± 0.91	< 0.001
<b>Temporal contraction</b>					
	32	5.78 ± 1 <sup>φ,ψ</sup>	6.46 ± 1.08 <sup>ψ</sup>	6.66 ± 1.09	< 0.001

<sup>a</sup>Repeated measures ANOVA analysis

<sup>φ,ψ</sup>It shows a significant difference compared to the Bonferroni post-hoc test; <sup>φ</sup>Compared to the 3. month; <sup>ψ</sup>Compared to the 6. month

There was no statistically significant difference between the right and left sides for all muscles in USG measurements ( $p > 0.05$ ) and there was a high level of positive correlation ( $r > 0.80$ ,  $p < 0.001$ ). The mean values of the right and left sides of the masseter and temporal muscles were used in the statistical analysis of muscle thickness measurements.

All muscle thickness measurements were statistically significantly different from baseline to 3rd month, from baseline to 6th month, and from 3rd month to 6th month ( $p < 0.05$ ) (Table 2). All muscle thickness values increased from baseline to 3rd month and from 3rd month to 6th month. When the three measurements of the masseter and temporal muscles were compared, the increase in thickness in the first 3 months was found to be greater than the increase in the following 3 months (Table 2).

Gender and age interactions were not found to be significant in the time-dependent changes in muscle thickness measurements ( $p > 0.05$ ).

The correlation between masseter muscle thickness and periodontal indices was evaluated with Pearson or Spearman correlation tests. A weak correlation was found between masseter rest-baseline and GI and PI before treatment, and between masseter contraction-baseline and GI and PI before treatment. There was no statistically significant correlation between other masseter muscle thickness measurements and periodontal indices (Table 3).

## Discussion

It is reported that USG is a reproducible and reliable method for the measurement of masticatory muscle [13, 14]. There are studies evaluating the thickness of the masseter and temporal muscles with USG in various conditions such as bruxism, temporomandibular dysfunction, and chronic periodontitis [15–17]. In the present study, considering its advantages over other imaging methods, it was decided to evaluate the masticatory muscles by USG. It was aimed to evaluate the masticatory performance of chronic periodontitis patients by measuring the thickness of the masseter and anterior temporal muscles with USG before and after periodontal treatment.

In studies using various methods, it has been reported that there is a relationship between the thickness of the masticatory muscles and the functional activity of the muscle [11]. In a study evaluating the thickness of the masticatory muscles by USG, the thickness of the masseter muscle was found to be significantly related to the bite force [18]. In the study of Georgiakaki et al., it was shown that there is a positive correlation between the masseter muscle thickness measured by USG and the electromyographic activity of the muscle. As the muscle thickness increases, the muscle fibers also increase in size and thus the muscle reveals more electromyographic activity [11].

There are studies in the literature that reported that periodontitis causes changes in masticatory functions. Alkan et al. Found that healthy individuals have higher bite force than individuals with periodontitis in their study with pressure-sensitive sheets [5]. Similarly, in the study of Palinkas et al., lower bite force was observed in patients in the periodontitis group compared to healthy individuals [19]. In contrast to these studies, another study reported that patients with reduced periodontal tissue support were able to generate similar maximum bite forces as healthy subjects [20]. Differences in results may be due to differences in measurement methods.

Periodontal treatment improves masticatory function [6, 10]. Pereira et al. Evaluated masticatory performance

**Table 3** Correlation between masseter muscle thickness and periodontal indices

			<b>PPD Before treatment</b>	<b>CAL Before treatment</b>	<b>GI Before treatment</b>	<b>PI Before treatment</b>
MR-Baseline	<b>CC</b>		−0.001	0.008	0.422	0.483
	<b>p</b>		0.997	0.965	<b>0.016*</b>	<b>0.005*</b>
MC-Baseline	<b>CC</b>		−0.012	0.010	0.388	0.356
	<b>p</b>		0.947	0.957	<b>0.028*</b>	<b>0.046*</b>
			<b>PPD After treatment</b>	<b>CAL After treatment</b>	<b>GI After treatment</b>	<b>PI After treatment</b>
MR-3. Month	<b>CC</b>		0.052	0.060	−0.235	0.088
	<b>p</b>		0.777	0.743	0.196	0.632
MR-6. Month	<b>CC</b>		0.171	0.184	−0.190	0.191
	<b>p</b>		0.351	0.313	0.297	0.295
MC-3. Month	<b>CC</b>		0.173	0.192	−0.238	0.208
	<b>p</b>		0.345	0.292	0.190	0.254
MC-6. Month	<b>CC</b>		0.166	0.191	−0.254	0.203
	<b>p</b>		0.364	0.294	0.160	0.266

Pearson or Spearman correlations

CC correlation coefficient (MR masseter rest, MC masseter contraction, PPD probing pocket depth, CAL clinical attachment loss, GI gingival index, PI plaque index)

\*Significant difference between groups is indicated by  $*p < 0.05$ .

before and after periodontal treatment and found improvement in masticatory performance after periodontal treatment [10]. Alshams et al. Reported that non-surgical periodontal treatment had a positive effect on objective measures of masticatory function. It has been reported that with conservative periodontal treatment in 3 months, the periodontal conditions of the patients improved significantly compared to the initial state and a significant improvement in bite force was observed [6]. Consistent with previous literature findings, in the present study, the thickness of the masticatory muscles was found to be higher after periodontal treatment. Interestingly, only a weak correlation was observed with the average clinical periodontal indices and masseter muscle thickness. This finding may suggest that the muscle increase and improved chewing efficiency after periodontal treatment may be related to the healing of the periodontal ligament in which the mechanoreceptors involved in mechanotransduction and chewing motor control are located, rather than the clinical indices which represents the superficial health of the tissues.

It has been stated in the literature that masticatory capacity can be measured by masseter muscle thickness and bite force [17]. In the present study, the thickness of the masseter and anterior temporal muscles as an indicator of masticatory function was evaluated by USG. The results of the study show that the thickness of the masticatory muscles increases after periodontal treatment. The hypothesis in the presented study is that periodontitis adversely affects the function of the masticatory muscles and periodontal treatment increases the performance of the masticatory muscles. Considering

the information in the literature, it was considered that the masticatory performance of the patients increased according to present study findings.

In the present study, when the three measurements of the masseter and temporal muscles were compared, the increase in thickness in the first 3 months was found to be greater than the increase in the following 3 months. These results are in line with a study suggesting that most clinical and microbial changes occur within the first 3 months after periodontal therapy [21].

Masseter muscle thickness of healthy individuals was evaluated by USG. Minami et al. reported masseter muscle thickness in healthy volunteers as 9.9 mm at rest and 13.1 mm at contraction [22]. In another study, the masseter muscle thickness was found to be 9.8 mm at rest and 12.4 mm at contraction in females, and 11.3 mm at rest and 14.7 mm at contraction in males [23]. In the present study, while masseter muscle thickness before periodontal treatment was lower than in the literature, it was determined that masseter muscle thickness after periodontal treatment was similar to healthy subjects.

The relationship between age and masticatory performance was investigated. Ikebe et al. suggested that if natural dentition is preserved, masticatory performance will not decrease due to aging alone [24]. In the present study, age was not found to be significant in time-dependent changes in muscle thickness measurements. It might be attributed to the fact that all participants had at least 20 natural teeth in the present study.

The relationship between gender and masticatory performance has been studied in the literature. Shiga et al.



reported that males had higher bite force and masticatory performance than females [25]. However, there are also studies suggesting that gender does not affect masticatory performance [24, 26]. In the present study, gender was not found to be significant in time-dependent changes in muscle thickness measurements.

In the present study, no difference in rest or contraction was observed between the right and left sides of the masseter and temporal muscles, and a high similarity was observed between the two sides. The reason for this can be considered as the inclusion criteria of at least four dental units in the posterior region on both the right and left sides. These findings are consistent with the findings of a previous study [17].

Best to our knowledge, there is no previous study in the literature that evaluated the thickness of the masticatory muscles and masticatory performances of chronic periodontitis patients with USG before and after periodontal treatment. Applying appropriate periodontal treatment to chronic periodontitis patients can prevent future problems such as masticatory muscle atrophy or digestive problems due to inability to chew. These problems also reduce the quality of life of individuals. It was considered that the findings of the present study will contribute to the literature.

## Conclusion

In the present study, it has been shown that periodontal treatment increases the thickness of the masticatory muscles of periodontitis patients, as well as the masticatory performance. Patients with periodontitis should be referred for periodontal treatment without wasting time. Studies with a larger study population and longer follow-up periods should be planned in the future.

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**Author contributions** Study idea/hypothesis: B.T.U., D.S.C. Study design: B.T.U., D.S.C., B.E., B.A. Data collection: B.T.U., B.A., G.A. Literature review: B.T.U., D.S.C., İ.G.A. Analysis and/or interpretation of results: H.D., B.T.U. Article writing: B.T.U., D.S.C., B.E. All authors read and approved the final manuscript.

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**Data availability** The data used and analyzed in the present study are available from the corresponding author upon reasonable request.

## Declarations

**Conflict of interest** The authors declare that they have no conflict of interest.

**Ethical approval** This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Ethics

Committee of Çukurova University (date: 05.11.2021, meeting no: 116, decision no: 71).

**Informed consent** Informed consent was obtained from all individual participants included in the study.

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