The effect of unilateral partial edentulism to muscle thickness

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ABSTRACT

Objectives: Teeth and muscles play a very important role for occlusal equilibrium and function. When tooth loss begins, it may also affect the function of the muscle tissues.

Methods: The thickness of the masseter and anterior temporalis muscles were measured bilaterally in 30 healthy fully dentate adults and in 30 unilateral edentulous patients by using ultrasonographic imaging. All scans were carried out by the same radiologist to eliminate the inter-observer difference, using a real time scanner (Toshiba SSA- 270 A Japan). A 7.5 MHz linear transducer was used. The transducer was held against the cheek with light pressure. The effect of age, sex, duration of the partial edentulism, unilateral chewing habits of the individuals to the muscle thickness were also evaluated. In all subjects, facial proportion index was also determined.

Results: No study has been found in the literature concerning the masticatory muscle thickness in unilateral partial edentulous patients. Therefore, the main purpose of this study was to compare and establish the differences of the muscle thicknesses between dentate and edentulous sides in unilateral partial edentulous patients with ultrasonography and to test whether the variation in the thickness of the muscle is related to the variation in the facial morphology using the facial proportional indices in the study groups. In the present study, ultrasonography revealed a large variation in the thicknesses of the masseter and temporalis muscles in experimental and control groups, during both relaxed and contracted conditions. The thicknesses of the muscles in females during both relaxed and contracted conditions were less than those in males in both control and experimental groups. In experimental group, a high negative correlation was found between the thickness of the masseter muscle and Facial proportion Index (FPI) in females, however, the statistical analysis showed no significant difference in males. Also, a high negative correlation was found in control group, especially in females. There was no statistically significant relationship between thicknesses of the muscles and age of the subjects in both groups. There was no statistically significant relationship between unilateral chewing habits and muscle thickness. In this study, the duration of partial edentulism did not affect the thickness of the muscles.

Conclusion: Further research is required to study muscular atrophy for comparison with total edentulism.

Saudi Med J 2003; Vol. 24 (12): 1352-1359

Relationships between edentulism, function and parafunction, temporomandibular joint, musculature and the nervous system are important.[1] In the review of the literature, symmetry of muscle size on the right and left side and morphology within each individual are important. Variation between individuals relates to a broad range of factors, such as skeletal size (genetic and or growth related), age, masticatory habits and general health.[2,3] In light of the literature possible relationships between the thickness of the masseter muscle and facial morphology in different individuals have been studied.[4,5] The Facial

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Received 15th March 2003. Accepted for publication in final form 10th September 2003.

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proportion index (FPI) is an index for determining the patients facial form (facial tendency).[6] The Facial proportion index is expressed as anterior lower facial height (ALFH) minus anterior upper facial height (AUFH) in healthy adults and in unilateral partial edentulous patients in the study. With the advent of modern imaging techniques, it has become possible to measure the size of the masticatory muscles in vivo.[4,5,7-12] The techniques available for measuring muscle cross-section in vivo are; computed tomography, magnetic resonance imaging, and ultrasonographic imaging.[8] The first imaging technique used for direct measurements of muscle size in living human beings was ultrasonography. For soft tissue imaging ultrasonography is superior to radiographs.[13] Ultrasonographic imaging is a rapid, inexpensive, noninvasive technique and, in contrast to computed tomography, it has no known cumulative biological effect.[4,5,8,9,14-18] Weijs and Hillen[19] published their results on the masticatory muscle thickness in adults, as registered by computed tomography. The method was reliable, but the radiographic exposure of normal individuals was very limited due to ethical reasons. As stated the evidence as to whether contracted or relaxed muscles correlate more closely with facial form is conflicting[5] and it needs more study with regards to this subject. It is conflicting whether contracted or relaxed muscles correlate more closely with facial form.

Muscle function relates to muscle size. The masseter muscle is one of the powerful muscles that provide the force necessary to chew efficiently.[20] Although mastication can occur bilaterally, 78% of observed subjects have a preferred side where the majority of chewing occurs. This is normally the side with the greatest number of tooth contacts during lateral glide.[21] Unilateral partial edentulous subjects mainly use the dentate side, and this is where the majority of the chewing occurs.

The purpose of this study was to measure the masseter and anterior temporalis muscle thicknesses while the teeth were occluding gently and when contracted during maximal clenching and to test whether the variation in the thickness of the muscle is related to the variation in the facial morphology in fully dentate healthy subjects and in unilateral edentulous patients. Also, the effect of age, sex, duration of partial edentulism and unilateral chewing habits to muscle thickness in the 2 groups were evaluated.

Methods. The thickness of the masseter and anterior temporalis muscles were measured bilaterally in 30 healthy fully dentate adults and in 30 unilateral edentulous patients by using ultrasonographic imaging. Thirty partially unilateral edentulous patients constituted the experimental group as group E. The group was comprised of 15 males and 15 females patients who attended the prosthetic department for construction of prosthesis, with age ranges of 22-45 years, who had unilateral edentulism in the lower jaw behind the canines in the posterior region and were fully dentate in the upper jaw. If any problems related to the muscles were not recognized in ultrasonographic scans; further investigations were planned. Patients with any muscle illnesses such as McArdel's syndrome, muscle spasm, pain, and any parafunctional habits were excluded. Thirty fully dentate individuals, 15 males and 15 females, whose ages ranged from 22-45 years were selected as controls (Cb). The selection criteria for the control group were as follows: No missing teeth in the anterior and posterior region (apart from third molars), Angle Class I molar occlusion with normal anterior relationship, no pain in the TMJ, no history of orthodontic treatment, no history of orthognathic surgery, no facial asymmetry, no parafunctions such as bruxism. The experimental group was further subdivided according to the duration of partial edentulism, partial edentulism up to 2 years as subgroup Ea (<2 years) and partial edentulism between 2 and 4 years as subgroup Eb. All subjects gave informed consent before the study.

By using the same method of Kiliaridis and Kalebo,[4] all scans were carried out by the same radiologist to eliminate the inter-observer difference, using a real time scanner (Toshiba SSA- 270 A, Japan). A 7.5 MHz linear transducer was used. The transducer was held against the cheek with light pressure. The transducer was tilted until the ramus was depicted on the screen as a sharp white line to make one it was perpendicular to the ramus. An Air-tight inert gel (Bluescan Gel, United States of America) was applied on the skin surface, the transducer was placed and transverse scans were carried out. Contrast between muscle and subcutaneous tissue was enhanced by asking the subject to clench and relax alternately. Masseter and anterior temporalis muscles were found with real time ultrasonographic scanning. Scanning the masseter obliquely would increase the thickness of the muscle. Ultrasonographic measurements of the masseter was made at the midpoint between anterior and posterior borders of the muscle on the line drawn between tragion and commissure. Ultrasonographic measurements of the anterior temporalis were made at the midpoint between anterior and posterior borders of the muscle, 5 cm above the Frankfurt plane. The imaging and the measurements were performed twice and bilaterally in both groups with the subject seated in an upright position, with the head in natural posture, under 2 different conditions: when the muscle was relaxed while the teeth were occluding gently, and when contracted during maximal clenching. In the experimental group the measurements of the muscle thickness in both dentate and edentulous sides were compared with each other so dentate side was selected as control group-a (group Ca). Then the measurements of the experimental group were compared with the measurements of the control group-b (group Cb). In

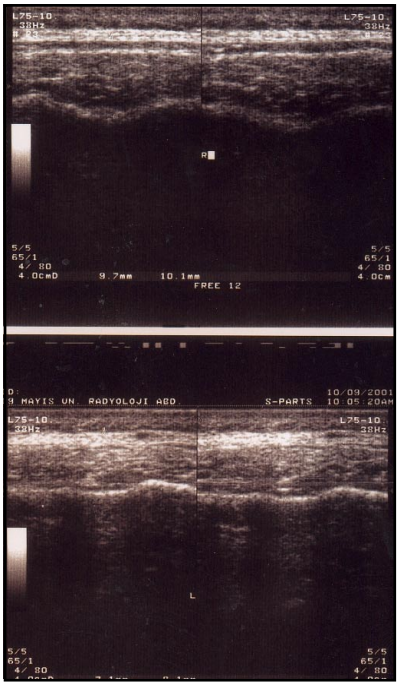

Figure 1 - Ultrasonographic image of the thickness (mm) of masseter muscle in both relaxed and contracted conditions in experimental group.

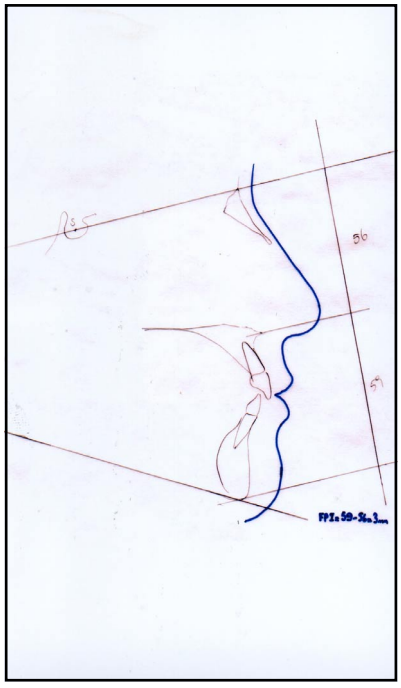

Figure 2 - Cephalometric measurement points on the cephalograms.

the photographs, the relaxed position of the muscle was shown in the left illustration, and the contracted position was shown in the right illustration **(Figure 1)**. The effect of age, sex, duration of the partial edentulism, unilateral chewing habits of the individuals to the muscle thickness were also evaluated. Data of muscle thickness in millimeters (mm) were collected and statistically computed for: Comparison of muscle thickness in experimental and control groups in relaxed and contracted positions. Effect of the duration of the partial edentulism to muscle thickness in experimental group. Effect of unilateral chewing habits to muscle thickness in controls. Effect of unilateral chewing habits to muscle thickness in experimental group. Effect of age and sex on muscle thickness.

The error of the method (SE) in the ultrasound technique was calculated by double recordings of imaging and measurements of the thickness of the masseter and anterior temporalis muscles by use of Dahlberg's formula4: $Se=\sqrt{Sd\ 2/2n}$(d=the difference between the second and the first recordings, n=the number of double determinations). The error of the thickness of the masseter was found to be small, not exceeding 0.22 mm during contraction and 0.38 mm during relaxation. The error of the thickness of the anterior temporalis was also found to be small, not exceeding 0.35 mm during contraction and 0.41 mm during relaxation. Cephalometric radiographic views of all subjects were taken in a standardized manner (Siemens Orthophos, 90kvp, Germany) so that their facial morphology could be determined (Opdebeeck 1978). The following cephalometric measurements were used: a-ATFH or N-Me. Anterior total facial height. Nasion to Menton have been measured along a perpendicular to SN (Cella-Nasion), b-AUFH or N-ANS. Anterior upper facial height. Nasion to anterior nasal spine has been measured along a perpendicular to SN. c-ALFH or ANS-Me. Anterior nasal spine to Menton has been measured along a perpendicular to SN. FPI (facial proportion index) was determined by ALFH minus AUFH **(Figure 2)**. When the index was equal to 10 patient had a normal facial tendency. When the sum was smaller than 10 or greater than 10, the patient had a short facial tendency or a long facial tendency.Student t test, Paired t test and Correlation analysis was used for statistical analysis.

Results. The mean thickness of the muscles in females during both relaxed and contracted positions were less than males in both groups, but the difference was not significant ($p>0.05$, **Table 1**). In group E, the thickness of the masseter muscle in relaxed position ranged from 6.95-14.3 mm (mean 10.51 ± 0.56 mm) in males and from 6.45-13.1 mm (mean 9.28 ± 0.53 mm) in females and the thickness of the anterior temporalis muscle ranged from 5.7-11.2 mm (mean 8.55 ± 0.35

Table 1 - Statistical analysis of anterior temporalis and masseter muscle thickness (mm) according to sex (student T test).

Groups	Muscles	Side	Condition	Sex	Mean	SD	SE	*P*
E (partially unilateral edentulous)	Temporal	Right	Relaxed	M	8,55	1,51	0,39	0,43
				F	8,09	1,62	0,42	
			Contracted	M	9,65	1,68	0,43	0,46
				F	9,13	2,03	0,52	
		Left	Relaxed	M	8,55	1,20	0,31	0,36
				F	8,06	1,65	0,43	
			Contracted	M	9,58	1,41	0,36	0,38
				F	8,90	2,56	0,66	
	Masseter	Right	Relaxed	M	10,59	2,35	0,61	0,14
				F	9,45	1,75	0,45	
			Contracted	M	13,77	2,54	0,66	0,03*
				F	11,98	1,74	0,45	
		Left	Relaxed	M	10,42	2,01	0,52	0,07
				F	9,11	1,77	0,46	
			Contracted	M	13,55	2,65	0,69	0,02*
				F	11,57	1,64	0,42	
Cb (controls)	Temporal	Right	Relaxed	M	9,48	1,08	0,28	0,38
				F	9,09	1,28	0,33	
			Contracted	M	10,31	2,94	0,76	0,80
				F	10,10	1,40	0,36	
		Left	Relaxed	M	9,16	1,77	0,46	0,27
				F	8,56	1,07	0,28	
			Contracted	M	10,49	2,11	0,54	0,33
				F	9,87	1,28	0,33	
	Masseter	Right	Relaxed	M	10,78	1,39	0,36	0,03*
				F	9,65	1,38	0,36	
			Contracted	M	15,43	1,70	0,44	0,01*
				F	13,67	1,51	0,39	
		Left	Relaxed	M	10,08	2,96	0,76	0,55
				F	9,57	1,24	0,32	
			Contracted	M	14,55	4,35	1,12	0,30
				F	13,30	1,46	0,38	

SE - standard error of mean, SD - standard deviation, *P* - *p* value

mm) in males and from 5.95 to 11.65 mm (mean 8.08 ± 0.42 mm) in females. In group E, the thickness of the masseter muscle in contracted position ranged from 9.65-18.55 mm (mean 13.66 ± 0.67 mm) in males and from 9.15-14.9 mm (mean 11.77 ± 0.44 mm) in females and the thickness of the anterior temporalis muscle ranged from 6.25 to 12.25 mm (mean 9.61 ± 0.40 mm) in males and from 5.3 to 13.8mm (mean 9.02 ± 0.60 mm) in females. In control group-b, the thickness of the masseter muscle in relaxed condition ranged from 8.8-13.85 mm (mean 10.43 ± 0.60 mm) in males and from 7.5-11.95 mm (mean 9.61 ± 0.34 mm) in females and the thickness of the anterior temporalis muscle ranged from 6.9-12.6 mm (mean 9.32 ± 0.37mm) in males and from 7.3-10.9 mm (mean 8.83 ± 0.28mm) in females. In control group-b, the thickness of the masseter muscle in contracted position ranged from 12.15-18.50 mm (mean 14.99 ± 0.85 mm) in males and from 11.25-6.60 mm (mean 13.49 ± 0.38 mm) in females and the thickness of the anterior temporalis muscle ranged from 5.10-15.65 mm (mean 10.4 ± 0.66 mm) in men and from 8.25-13.0 mm (mean 9.98 ± 0.35 mm) in females. In group E, bilateral masseter muscle thickness in contracted position was greater in males with statistical significance $p<0.05$. In control group-b only the right masseter muscle thickness in both conditions were greater in males with statistical significance ($p<0.05$). Bilateral anterior temporalis muscle thickness in both sexes was not significant statistically ($p>0.05$, **Table 1**). The ultrasonographically determined muscle thicknesses increased significantly from the relaxed to the maximally contracted state in both groups ($p<0.01$, **Table 2**). This difference was visible on the scans. There was no statistically significant difference between dentate and partial edentulous side (control group, Ca) in experimental group in both relaxed and contracted position ($p>0.05$). It seemed that the patient's in-group E, had the habit of chewing on the side where the natural teeth were in this study. Control group-b subjects reported that they tend to use only one side although they have teeth in both sides. The muscle thickness on the side which chewing habit was present was not found to be greater significantly in comparison with the opposite side. No statistical significant reduction in muscle thickness was found on non-chewing side in the experimental group ($p>0.05$, **Table 3**). The relationship between duration of partial

Table 2 - Statistical analysis of muscle thickness (mm) in both relaxed and contracted conditions of experimental and control groups (Paired T test).

Groups	n	Muscles	Side	Condition	Mean	SD	SE	*P*
E	30	Temporal	Right	Relaxed	8,32	1,56	0,28	<0.00
				Contracted	9,39	1,85	0,34	
	30		Left	Relaxed	8,31	1,44	0,26	<0.00
				Contracted	9,24	2,06	0,38	
	30	Masseter	Right	Relaxed	10,02	2,11	0,39	<0.00
				Contracted	12,88	2,33	0,43	
	30		Left	Relaxed	9,76	1,97	0,36	<0.00
				Contracted	12,56	2,39	0,44	
Cb	30	Temporal	Right	Relaxed	9,29	1,18	0,21	<0.08
				Contracted	10,21	2,27	0,41	
	30		Left	Relaxed	8,86	1,47	0,27	<0.00
				Contracted	10,18	1,74	0,32	
	30	Masseter	Right	Relaxed	10,21	1,48	0,27	<0.00
				Contracted	14,55	1,82	0,33	
	30		Left	Relaxed	9,83	2,24	0,41	<0.00
				Contracted	13,92	3,25	0,59	

SD - standard deviation, SE - standard error of mean, *P* - *p* value

edentulism and muscle thickness was not statistically significant (p>0.05, **Table 4**). There was a statistically significant correlation between the FPI, and the thickness of masseter muscle in both relaxed and contracted positions (**Table 5**). According to gender, in the experimental group in the relaxed position the correlation coefficients were r=-0.499 and r=-0.794 for both males and females and in contracted position correlation coefficients were **r=-** r =-0.619 and r=-0.747 for both males and females patients. In the control group-b in relaxed position correlation coefficients were r=-0.271 and r=-0.510 for both males and females and in contracted positions correlation coefficients were r=-0.206 and r=-0.520 for both males and females. The thickness of masseter muscle was strongly related to the facial proportion index in the females, but not in males, which means that females with a thin masseter had a long facial tendency. Correlation coefficients were higher in experimental group than control group-b, with relation to gender.

Discussion. Since the edentulous side in partial edentulous patients is not often used during chewing and no literature has been seen regarding the difference between dentate and edentulous side muscles in partial edentulous patients as of unilateral chewing habits, this study was planned. The masseter muscle contributes to higher activity in the clenching effort.[7,22] The anterior temporalis varies less in cross-section than do the other jaw muscles and shows a relatively weak correlation with other masticatory muscle cross sections.[19] The influence of the activity of the attached muscles is more apparent in the maxillofacial bones as compared with the long bones of the extremities.[23] Recently, muscle thickness has been considered as one indicator of jaw muscle function.[4,12] Since tooth loss may cause decreased workload on masticatory muscles, it may affect muscle thickness. On the other hand, literature lacks multivariate studies designed to correlate changes in jaw muscle activity and their size or thickness in partially unilaterally edentulous patients with different duration of edentulism. No studies were found in the available literature where a comparison of the masseter and anterior temporalis muscle thickness has been recorded ultrasonographically in partially unilaterally edentulous subjects.

Muscle area and structural alterations of the masticatory muscles can be visualized by computed

Table 3 - Statistical analysis of anterior temporalis masseter muscle thickness (mm) according to chewing side in both groups (Paired T test).

Groups	n	Chewing Side	Muscles	Conditions	Side	Mean	SD	SE	*P*
E	18	Right	Temporal	Relaxed	Right	8,22	1,50	0,35	0,93
					Left	8,21	1,43	0,34	
				Contracted	Right	9,17	1,70	0,40	0,76
					Left	9,08	2,24	0,53	
	12	Left		Relaxed	Right	8,46	1,70	0,49	1,00
					Left	8,46	1,52	0,44	
				Contracted	Right	9,73	2,08	0,60	0,57
					Left	9,48	1,82	0,53	
	18	Right	Masseter	Relaxed	Right	10,00	2,18	0,51	0,09
					Left	9,36	1,93	0,46	
				Contracted	Right	12,58	2,31	0,55	0,16
					Left	12,06	2,18	0,51	
	12	Left		Relaxed	Right	10,04	2,11	0,61	0,26
					Left	10,36	1,96	0,57	
				Contracted	Right	13,33	2,38	0,69	0,98
					Left	13,32	2,59	0,75	
Cb	19	Right	Temporal	Relaxed	Right	9,02	1,20	0,28	0,11
					Left	8,56	1,49	0,34	
				Contracted	Right	10,14	1,93	0,44	0,10
					Left	9,73	1,49	0,34	
	11	Left		Relaxed	Right	9,75	1,02	0,31	0,24
					Left	9,37	1,35	0,41	
				Contracted	Right	10,32	2,86	0,86	0,53
					Left	10,96	1,94	0,58	
	19	Right	Masseter	Relaxed	Right	10,18	1,55	0,36	0,31
					Left	10,02	1,44	0,33	
				Contracted	Right	14,48	1,82	0,42	0,37
					Left	14,26	1,96	0,45	
	11	Left		Relaxed	Right	10,26	1,42	0,43	0,47
					Left	9,49	3,27	0,99	
				Contracted	Right	14,66	1,91	0,57	0,43
						13,35	4,81	1,45	

SD - standard deviation, SE - standard error of mean, *P* - *p* value

tomography (CT) scanning or magnetic resonance imaging (MRI).[2,3] The great advantage of CT is that, it can depict soft tissue as well as bony structures on the same scan. Ultrasonography has been used by a number of investigators to measure masseter and anterior temporalis muscle dimensions.[4,7,9,24,25] However, in partially unilaterally edentulous patients ultrasonography has not been evaluated previously for quantitative studies of the masticatory muscles. In the present study, with the present method,[4] it was possible to measure the muscle thicknesses with good reproducibility. In the present study ultrasonography revealed a large variation in the thickness of the masseter and anterior temporalis muscles among adult individuals during both relaxed and contracted positions in both groups, with no statistically significant difference. This is in agreement with the findings of Kiliaridis and Kalebo,[4] Weijs and Hillen,[19] Van Spronsen et al[26] and Hannam and Wood.[27]

Bakke et al[12] stressed the importance of clenched muscle measurements. Although Prabhu and Munshi[9] reported that the muscles thickness was higher in the contracted states for Angle class I molar relationship with and without cases of open bite, but there was no statistically significant difference. In the present study, the thickness of the contracted muscles was greater than those of the relaxed, and the difference was statistically significant. This is an expected result due to muscle physiology; in relaxed states the muscle tone is lower than in the contracted state.[28] Raadsheer et al[8] and Kiliaridis and Kalebo[4] argued that the use of the ultrasonic transducer tends to compress relaxed muscles, resulting in erroneously small thickness measurements and reduced reproducibility than in clenched scans. However in the present study while applying the superficial transducer the radiologist did not use any pressure on the muscles, holding the transducer in the correct position. In contrast to Kiliaridis and Kalebo[4] who used a linear array transducer which is originally used for deep tissue scanning in their study, our study used a superficial transducer which is better suited for ultrasonographic scanning as the masseter and anterior temporalis are superficially placed muscles. With the advent of the ultrasonographic technology, superficial transducers provide a detailed evaluation and high resolution imaging, such as the case in our study.

In this study the masseter and anterior temporalis muscle thickness in females were less than males in both groups and during both relaxed and contracted

Table 4 - Statistical analysis of anterior temporalis and masseter muscle thickness (mm) according to duration of partial edentulism of experimental group (Paired T - test).

Duration of partial edentulism	n	Muscles	Conditions	Side	Mean	SD	SE
			Relaxed	Right	7,99	1,79	0,54
	11	Temporal		Left	7,97	1,86	0,56
			Contracted	Right	9,04	2,10	0,63
Ea				Left	8,90	2,88	0,87
	11		Relaxed	Right	9,54	1,65	0,50
(<2 years)		Masseter		Left	9,17	1,86	0,56
			Contracted	Right	12,06	2,02	0,61
	19			Left	11,72	2,12	0,64
			Relaxed	Right	8,51	1,42	0,33
		Temporal		Left	8,49	1,44	0,26
	19		Contracted	Right	9,59	1,71	0,39
Eb				Left	9,44	1,45	0,33
			Relaxed	Right	10,29	2,34	0,54
(2-4 years)		Masseter		Left	10,11	2,00	0,46
			Contracted	Right	13,35	2,42	0,55
				Left	13,05	2,45	0,56

SD - standard deviation, SE - standard error of mean, *P* - *p* value

Table 5 - Correlation coefficients between the thickness (mm) of masseter muscle and facial proportion index (FPI).

Groups	Muscle thickness in relaxed condition -0,645	Muscle thickness in contracted condition -0,626
Experimental Group	p=0,00012 -0,336	p=0,00021 -0,374
Control Group-b	p=0,069 -0,526	p=0,042 -0,534
Total	**p=0,0008**	**p=0,0016**

positions. This agrees with the findings of literature[4,5] in that anatomically males usually have stronger muscles than females do.

Masseter and anterior temporalis muscle thickness were greater in normal adults than unilaterally partially edentulous patients, however, the difference was not statistically significant. The results show that unilateral edentulism does not cause a significant reduction of the thickness of the masticatory muscles. This can be explained by the fact that, since in unilateral partial edentulous subjects the side, which they use, is the dentate side where the majority of chewing occurs a decreased workload on the edentulous side may affect the masticatory muscles. Decreased workload may cause atrophic cells that may have diminished function, but they are not dead. In unilateral partial edentulous patients (Group E) the masticatory muscle thickness may differ in dentate and edentulous sides as of the decreased workload. The individual speaks, laughs and has also some gestures except chewing. During a day, the chewing duration is very little so it may not change the muscle size in dentate and edentulous sides. In this study individuals in experimental group had the habit of chewing on the side where the natural teeth were. However chewing habit did not seem to affect the muscle thicknesses neither in this group nor in the control group b. The rate of using both dentate and edentulous sides during chewing in partial edentulous patients (Group E) was studied to recognize if it would cause a change in the thickness of masticatory muscles.

An interesting finding was the high negative correlations between the muscle thickness and facial proportion index in females, but not in males. Our observations concerning the correlation of the thickness of the masseter muscle and facial form tendency was in agreement with previous studies by Kiliaridis and Kalebo,[4] Weijs and Hillen[19] and Hannam and Wood[27]

Discrepancies between the muscle measurement values in this study and those found by other investigators may be due to disparities between the

samples, differences in the location of muscle measurement points and the use of different imaging techniques with different investigators.[5,8,12] Therefore in this study we preferred using the method of Kiliaridis and Kalebo[4] to make comparison.

It has been stated that decrease in muscle thickness was found to be frequently observed with advanced age.[29] An age-related decrease of bite force followed a significant reduction of the cross-sectional area of the masseter muscle with increasing age in subjects between the ages of 20 and 90 years. Changes in the muscle mass were observed only after 35-years-old in the study of Newton et al.[30] However, no correlation was found between the thickness of the masseter and anterior temporalis muscles and the age of the subjects in 2 groups of this study. This finding contradicts with the study of Newton et al[30] who found a strong correlation between muscle thickness and age, but in accordance with previous studies[4,9] on which patient's ages were between 20–35 years, and 8-17 years. In this study the ages of the subjects ranged from 22-45 years old, it may differ from those of Newton's[30] who are over 45 years. It seems that atrophic changes in the muscles could become significant after 45-years-old.

Further, research is required to study muscular atrophy for comparison with total edentulism.

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