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The Relationship Between Submandibular Gland Size and Oral Health Status, Gender, Age, Body Mass Index in a Healthy Population: A Cross-Sectional Study

Sağlıklı Popülasyonda Submandibular Bez Büyüklüğü ile Ağız Sağlığı Durumu, Cinsiyet, Yaş, Beden Kitle İndeksi Arasındaki İlişki: Kesitsel Bir Çalışma

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ABSTRACT Objective: One of the indexes that best shows the oral health status is the decayed-missing-filled teeth (DMFT) index. 65% of the saliva secreted in the body is produced by the submandibular gland. One of the best imaging methods of the submandibular gland is ultrasound. The aim of this study is to investigate whether there is a relationship between the volume of the submandibular gland, the gland in which saliva is produced the most, and the DMFT index. In addition, changes in the size and volume of the submandibular salivary gland depending on age, gender and body mass index (BMI) were investigated using ultrasonography (USG). **Material and Methods:** In this study, 240 submandibular glands (right and left) of 120 patients were examined by USG. **Results:** Submandibular gland volume in males; was found to be higher than that of females ($p<0.05$). There was no statistically significant relationship between salivary gland volume and BMI, DMFT index ($p>0.05$). While the DMFT index increased with age, it did not change depending on gender. We found the mean volume of the right submandibular gland to be 4.21±0.839 cm^3 and the volume of the left submandibular gland to average 4.23±0.825 cm^3. The mean DMFT index was found to be 11.29±9.025. **Conclusion:** There is no relationship between submandibular gland size and DMFT index. There is no relationship between submandibular gland size and BMI index. In addition, males have a larger volume of submandibular glands than females.

Keywords: Ultrasonography; submandibular gland volume; decayed-missing-filled teeth index

ÖZET Amaç: Ağız sağlığı durumunu en iyi gösteren indekslerden biri çürük-eksik-dolgulu dişler [decayed-missing-filled teeth (DMFT)] indeksidir. Vücutta salgılanan tükürüğün %65'i submandibular bez tarafından üretilmektedir. Submandibular bezin en iyi görüntüleme yöntemlerinden biri de ultrasondur. Bu çalışmanın amacı, tükürüğün en çok üretildiği bez olan submandibular bez hacmi ile DMFT indeksi arasında ilişki olup olmadığını araştırmaktır. Ayrıca submandibular tükürük bezinin yaş, cinsiyet ve beden kitle indeksine (BKİ) bağlı olarak boyut ve hacmindeki değişiklikler ultrasonografi (USG) ile araştırıldı. **Gereç ve Yöntemler:** Bu çalışmada, 120 hastanın 240 submandibular bezi (sağ ve sol olmak üzere) USG ile incelendi. **Bulgular:** Erkeklerde submandibular bez hacim değerleri kadınlara göre daha yüksek bulundu ($p<0,05$). Tükürük bezi hacmi ile BKİ, DMFT indeksi arasında istatistiksel olarak anlamlı bir ilişki yoktu ($p>0,05$). DMFT indeksi yaşla birlikte artarken cinsiyete göre değişmedi. Sağ submandibular bezin ortalama hacmini 4,21±0,839 cm^3 ve sol submandibular bezin hacmini ortalama 4,23±0,825 cm^3 bulduk. Ortalama DMFT indeksi 11,29±9,025 olarak bulundu. **Sonuç:** Submandibular bez büyüklüğü ile DMFT indeksi arasında bir ilişki yoktur. Submandibular bez boyutu ile BKİ indeksi arasında bir ilişki yoktur. Ek olarak, erkeklerin kadınlardan daha büyük bir submandibular bez hacmi vardır.

Anahtar Kelimeler: Ultrasonografi; submandibular bez hacmi; çürük-eksik-dolgulu dişler indeksi

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The submandibular gland is located posterior to the submandibular triangle. In studies, the mean antero-posterior length of the submandibular glands was found to be 35 mm±5.7 mm, the superio-inferior length (paramandibular dimension, depth) 14.3 mm±2.9 mm, and the medio-lateral length (transverse dimension) 33.7 mm±5.4 mm.[1-3]

Ultrasonography (USG), depending on the difference in the sound permeability of the tissues; it is a radiological imaging method that provides real-time information about the state of tissues. USG is an important technique for imaging the salivary glands because it does not contain ionizing radiation and shows the localizations of the submandibular and parotid glands without superposition.

The decayed-missing-filled teeth (DMFT) index is an index recommended by the World Health Organization and used to evaluate the amount of decayed, missing, and filled teeth.[4] It was first described by Klein and Palmer in 1938.[5] The maximum score is set to 28 and the minimum score to be 0.

The aim of this study was to investigate whether there was a relationship between the DMFT index and the volume of the submandibular salivary glands on ultrasound in a healthy population. In addition, changes in the size and volume of the submandibular salivary gland depending on age, gender and body mass index (BMI) were investigated using USG.

MATERIAL AND METHODS

STUDY DESIGN

This study was carried out in the department of oral and maxillofacial radiology, and the compliance of this study with scientific ethical rules was approved by the Atatürk University Faculty of Dentistry Ethics Committee's decision numbered 2020/17 (date: June 19, 2020). It was performed in accordance with the principles of the Declaration of Helsinki. An informed consent form was obtained from the patients. A total of 120 patients between the ages of 15 and 81, who did not have any systemic disease, did not have a history of continuous drug use, did not smoke or drink alcohol were included in this study. To ensure the homogeneous of groups, 10 male and 10 female patients who were volunteered to participate in the study, in each age group in every decade, were included in the study. The 1st group was formed by 15-19, the 2nd group 20-29, the 3rd group 30-39, the 4th group 40-49, the 5th group 50-59 and the 6th group over 60 years old.

Volunteers were divided into 4 groups according to their BMI. 1st group: low weight (BMI below 18.5). 2nd group normal weight (BMI 18.5-24.9); 3rd group overweight (BMI 25-29.9) 4th group obese (BMI 30-40), 5th group extremely obese (BMI 40+). Extremely obese was not included in our study.

USG PROCEDURES AND MEASUREMENTS

Bilateral submandibular salivary glands of all patients were examined using the Toshiba Aplio 300 (Toshiba Corporation, Tokyo, Japan) USG device and a 12-MHz linear array transducer probe in the department of oral and maxillofacial radiology. In order to ensure standardization and minimize mobility during the USG examination, the patient was seated with the head fixed on the headrest, with the head extended in the submandibular gland examination. Ultrasonographic examination was performed by moving the probe extraorally to the region of the submandibular glands in the transversal plane (Figure 1).

After the location of the submandibular salivary gland was found, the probe was positioned to be parallel to the lower edge of the mandible. Caliper option was selected on the USG device to be able to measure. Then, the volume icon was clicked on the touch screen and the antero-posterior length of the submandibular gland was measured and recorded as dist 1. The second measurement, the superio-inferior measurement on the same image, was also made and recorded as dist 2. To measure the 3rd dimension, the probe was rotated longitudinally and held vertically to the body of the mandible, and the medio-lateral length of the submandibular gland was measured and recorded as dist 3. After the dimension measurement in these three planes, the volume calculation was made automatically by the device. The volumes of the right and left submandibular glands of 120 patients included in our study were calculated and recorded as described (Figure 2).

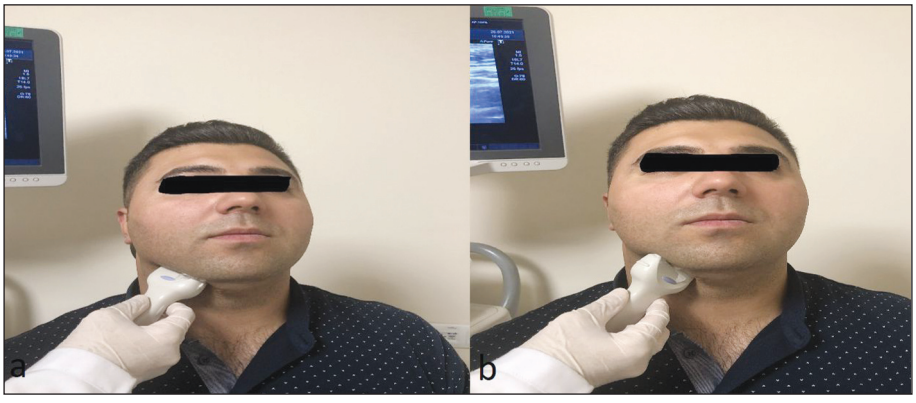

FIGURE 1: a-b) The submandibular gland was seated with the head in extension for size measurement. Ultrasonographic evaluation started transversal, and the probe was rotated longitudinally while calculating the volume of the submandibular salivary gland.

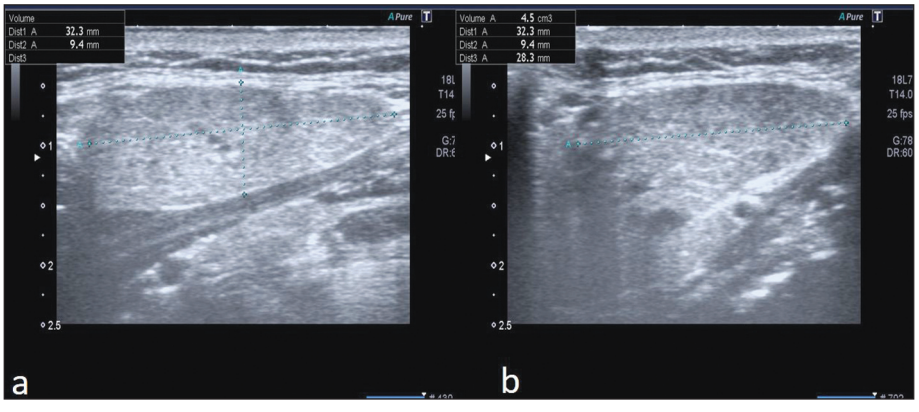

FIGURE 2: a-b) The antero-posterior length of the submandibular gland was measured and recorded as dist 1. The second measurement, the superio-inferior measurement on the same image, was also made and recorded as dist 2. 3. to measure the size, the probe was rotated longitudinally and held vertically to the body of the mandible, and the medio-lateral length of the submandibular gland was measured and recorded as dist 3. After the dimension measurement in these three planes, the volume calculation was made automatically by the device.

All measurements were made by the same observer with at least 3 years maxillofacial USG experience, and the reliability of the measurements was evaluated with the intra-observer correlation test.

The DMFT index was determined by routine clinical and radiological examinations in each patient. DMFT index of the volunteers were noted.

STATISTICAL ANALYSIS

One-way analysis of variance test was used to compare the anteroposterior length, mediolateral length, superioinferior length and volumes of the right and left submandibular glands according to age groups and BMI. When the p value was below 0.05, the post hoc Tukey test was used to determine between which groups the difference was. The indepent t-test was used to compare the anteroposterior length, mediolateral length, superioinferior length and volume of the right and left submandibular glands by gender.

Normality test was used to evaluate the relationship between DMFT index and submandibular gland volume. Since the data were not normally distributed, Spearman correlation test was used. The result was considered significant when $p<0.05$. Descriptive statistics were used to determine the mean and standard deviations of the DMFT index. Mann-Whitney U test was used to evaluate DMFT index according to gender and Kruskal-Wallis test was used to evaluate according to age groups. When the p value was below 0.05, Pairwise Comparisons test was used to determine between which groups the difference was.

RESULTS

Cronbach's alpha value was 0.991 in USG measurements, which was performed to evaluate the intra-observer agreement (95% confidence interval).

The ages of the participants ranged from 15 to 81. The mean age of the participants was 39.73±17.345.

In the present study, the mean antero-posterior length of the right submandibular gland was 29.12±3.391 mm; the mean superior-inferior length was 11.03±1.918 mm; the mean medio-lateral length was found to be 25.73±4.062 mm. The mean antero-posterior length of the left submandibular gland was 29.34±2.977 mm; the mean superior-inferior length was 11.09±2.439 mm; the mean medio-lateral length was found to be 25.52±4.547 mm (Table 1). In our study, we found the mean volume of the right submandibular gland to be 4.21±0.839 cm^3 and the volume of the left submandibular gland to average 4.23±0.825 cm^3 (Table 1).

Submandibular gland volume in male; was found to be higher than females. Females right submandibular glands volume 3.75±0.571 mm^3, left submandibular glands volume 3.78±0.613. Males right submandibular glands volume 4.67±0.816 mm^3, left submandibular glands volume 4.67±0.774 mm^3. In the present study, we concluded that the volumes of the right and left submandibular glands did not significantly change with BMI with age (Table 2) (p>0.05).

TABLE 1: Right and left submandibular salivary gland; mean and standard deviations lengths and volume.

	Mean	SD
Left submandibular antero-posterior (mm)	29.34	2.977
Right submandibular antero-posterior (mm)	29.12	3.391
Left submandibular medio-lateral (mm)	25.52	4.547
Right submandibular medio-lateral (mm)	25.73	4.062
Left submandibular superio-inferior (mm)	11.09	2.439
Right submandibular superio-inferior (mm)	11.03	1.918
Left submandibular volume (mm^3)	4.23	0.825
Right submandibular volume (mm^3)	4.21	0.839

SD: Standard deviation.

No significant correlation was found between submandibular gland volume, DMFT index (Spearman correlation coefficient; p>0.05).

The mean DMFT index was found to be 11.29±9.025. DMFT index did not show a significant difference according to gender (Table 3) (p<0.05). When the DMFT index was evaluated according to age groups, it was found that the DMFT index increased with age (Table 3) (p<0.05).

DISCUSSION

Although many studies of ultrasonic diagnosis in salivary glands have been published during the last years, specifications about the size of healthy salivary glands are not available from the literature. Normal values could be helpful in the diagnosis of diseases in which the size of the glands changes symmetrically.[2] For example, bilateral swelling of the parotid glands

TABLE 2: Right and left submandibular salivary gland; Statistical evaluation of anteroposterior, superio-inferior and medio-lateral lengths and volumes by gender, age and BMI.

	p^1 Gender	p^2 Age	p^3 BMI	Significant differences
Left submandibular anterio-posterior	0.609	0.396	0.962	
Right submandibular anterio-posterior	0.080	0.163	0.483	
Left submandibular medio-lateral	0.625	0.601	0.100	
Right submandibular medio-lateral	0.617	0.219	0.013*	2^b-4^b
Left submandibular superio-inferior	0.647	0.963	0.370	
Right submandibular superio-inferior	0.889	0.076	0.004*	1^b-2^b; 1^b-3^b
Left submandibular volume	0.008*	0.219	0.493	M>F
Right submandibular volume	0.001*	0.230	0.493	M>F

*p<0.05 (p^1: The indepent t-test. p^2: One-way analysis of variance test. p^3: One-way analysis of variance test. When the p value was below 0.05, the post hoc Tukey test). 1^a: 15-19; 2^a: 20-29; 3^a: 30-39; 4^a: 40-49 5^a: 50-59; 6^a: 60+ age groups. 1^b: Low weight BMI below 18.5; 2^b: Normal weight BMI 18.5-24.9; 3^b: Overweight BMI 25-29.9; 4^b: Obese BMI 30-40; 5^b: Extremely obese BMI 40+. Extremely obese was not included in our study. BMI: Body mass index; F: Female; M: Male.

TABLE 3: DMFT according to gender and age (1ª: 15-19; 2ª: 20-29; 3ª: 30-39; 4ª: 40-49 5ª: 50-59; 6ª: 60+ age groups).

	p[1] Gender	p[2] Age	Significant differences
DMFT index	0.235	0.000*	1ª-4ª; 1ª-5ª; 1ª-6ª; 2ª-4ª; 2ª-5ª; 2ª-6ª 3ª-5ª; 3ª-6ª; 4ª-6ª

*p<0.05. 1ª: 15-19; 2ª: 20-29; 3ª: 30-39; 4ª: 40-49 5ª: 50-59; 6ª: 60+ age groups. p[1]: Mann-Whitney U test. p[2]: Kruskal-Wallis test. When the p value was below 0.05, Pairwise Comparisons test was used to determine between which groups the difference was. DMFT: Decayed-missing-filled teeth.

would be expected in endemic parotitis and bilateral involution would be expected in Sjogren's syndrome or after radiation.[6,7] Although many authors stress that enlargement or involution is seen in some diseases, they do not give information on the basis from which changes in size should be determined, other than by comparison of both sides.[8-13] Therefore, we conducted a study on a healthy population to ensure standardization in our study.

While some studies did not find a statistically significant difference between the sizes and volumes of salivary glands and gender, a statistically significant difference was found in a study by Heo et al.[2,14,15] In the study performed by Brozzi et al. with USG, the volumes of both the parotid and submandibular glands of 33 individuals correlated with the individual's weight, height and BMI, but not with age.[14] In another study by Dost and Kaiser, it was found that the sizes of the parotid and submandibular glands did not differ significantly with gender and age in 50 healthy subjects (25 male, 25 female) without salivary gland disease.[2] In the present study, submandibular gland volume was found to be higher in males. However, there was no statistically significant relationship between submandibular gland volume and age and BMI.

Dost and Kaiser, in their study on 16 cadavers, they compared the size and volume of salivary glands measured by USG with actual measurements and found a statistically significant difference.[2] According to this study, Dost and Kaiser stated that trying to determine the actual volumes of the salivary glands ultrasonographically may be wrong but USG can be used to compare different patient groups.[2] In our study, the sizes and volumes of the submandibular salivary glands were compared between the groups in patients grouped according to age, gender and BMI in the healthy population.

Dost and Kaiser mean antero-posterior length in submandibular glands; they found an average of 35 mm±5.7 mm, a mean of 14.3 mm±2.9 mm in the superio-inferior length and 33.7 mm±5.4 mm in the medio-lateral length.[2] Our results are similar to these results. Wang et al. attempted to determine the mass and volume of normal submandibular glands in 220 subjects in vitro.[16] To evaluate this, they compared the measured values of the computed tomography (CT) volume reconstruction method and found the mean submandibular gland volume to be 11.55±2.41 cm^3 in vitro. These results were consistent with volume measurements using USG in the literature. The reason why the volume was smaller than the CT measurements in our study may be due to the inability to fully visualize the submandibular gland with USG, as it was stated by Dost and Kaiser.[2] In our study, after making the antero-posterior, superior-inferior and mediolateral measurements of the submandibular glands, the volume was automatically measured by the ultrasound device. The volume measurement logic of the ultrasound device is volume=length x width x height x 0.52, which is the prolate ellipsoid method.[17] However, as Dost and Kaiser stated in their article, while this formula is more successful in measuring the volumes of elliptical or spherical organs (thyroid gland and heart), it is not suitable for the submandibular gland. However, it can be used in comparative studies.[2]

We conclude that the volume of the submandibular salivary gland is greater in males than females. Wang et al. similarly found that the volume of the submandibular salivary gland was significantly higher in man than in women.[16] This is an expected result due to gender dimorphism. In the present study, we obtained the result that the volume of the submandibular salivary gland does not change with age. Similarly, Wang et al. found that the volume of the submandibular salivary gland does not change with age.[16]

The dimensions and volumes of the submandibular gland can be measured by USG. However, since the submandibular gland is located around

the bone structures, it cannot be fully visualized, but can be used in comparative studies.

For over 70 years, DMFT index has been used worldwide as the most important index to assess the state of oral and dental health. In addition, this index is the most important index used in epidemiological studies on the health status of the population.[18] This index determines the number of decayed teeth, the number of teeth treated, and the number of teeth lost due to decay.[19]

The findings of this study showed that as age increases, the DMFT index becomes more unfavorable. With aging, the number of decayed, missed, and filled teeth normally increases. With increasing the age, the DMFT index was higher.[20,21] In the present study, we found the mean and standard deviation of DMFT index to be 11.29±9.025. As our study included 120 patients between the ages of 15 and 81. Kamalabadi et al. in their study on 350 patients aged 25-55 years, they found the mean and standard deviation of the dmft index as 18.27±7.23.[22] We obtained the result that the DMFT index did not change with gender. This result supported some studies in the literature.[23,24]

Saliva; it has an important role in removing food residues on oral teeth, buffering acid created by microorganisms in dental plaque, and diluting sugar.[25] The anti-caries effect of saliva; It depends on the flow rate of saliva, saliva pH and buffering capacity, antimicrobial properties and defense elements in its content.[26-28] It has been suggested that there is a relationship between stimulated and unstimulated salivary flow rate values, parotid and submandibular salivary gland sizes, and BMI. Males with larger salivary gland sizes have been shown to have a greater stimulated salivary flow rate. In women, however, no relationship was found between stimulated salivary flow rate and salivary gland size.[29] It has been reported that there is a positive correlation between the unstimulated salivary flow rate and the size of the parotid and/or submandibular salivary glands in both sexes. Due to these studies available in the literature, we evaluated the relationship between DMFT index and submandibular gland volume. However in the present study, we did not find a significant relationship between the submandibular gland volume measured using USG and the DMFT index. The reason for this may be that the salivary glands contribute to unstimulated salivary flow at different rates. (20% from parotid, 65% from submandibular, 7% to 8% from sublingual, and less than 10% from numerous minor glands.).[30] There is no study in the literature investigating the relationship between submandibular salivary gland volume measured by USG and DMFT index.

LIMITATIONS

The limitation of our study is that it was conducted on patients presenting with dental problems.

CONCLUSION

There is no relationship between submandibular gland size, DMFT index, and BMI. It has been understood that salivary gland sizes alone are not effective on oral and dental health, and saliva is effective on oral and dental health along with many other features. In addition, males have a larger volume of submandibular glands than females. The size and volume of the submandibular gland can be measured by USG for comparison between various groups.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Fatma Çağlayan;* ***Design:*** *Esin Akol Görgün;* ***Control/Supervision:*** *Fatma Çağlayan;* ***Data Collection and/or Processing:*** *Esin Akol Görgün;* ***Analysis and/or Interpretation:*** *Esin Akol Görgün;* ***Literature Review:*** *Esin Akol Görgün;* ***Writing the Article:*** *Esin Akol Görgün;* ***Critical Review:*** *Fatma Çağlayan;* ***References and Fundings:*** *Esin Akol Görgün;* ***Materials:*** *Fatma Çağlayan.*

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