Original Article

Shear-wave Elastography of Palatine Tonsils: A Normative Study in Children

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Abstract

Background: Shear-wave elastography (SWE) was used to determine normal elasticity values of palatine tonsils (PTs) in children and adolescents who did not have any health problem, and the relationship between these values and various parameters influencing this result was examined. **Methods:** The current prospective study has been approved by the local Institutional Review Board. Our study included 122 people aged 2–18 years. SWE values for both PTs, as well as gender, age, and body mass index (BMI), were recorded. The Kolmogorov–Smirnov test was used to determine whether the data had a normal distribution. Numerical variables with a normal distribution are reported as mean ± standard deviation, while variables with a nonnormal distribution are reported as medians with minimum and maximum values. Numbers and percentages are used to report categorical variables. **Results:** The study group's average age was 10.77 ± 4.35 years. The mean SWE values were 9.89 ± 2.494 kPa for the right PT and 9.57 ± 2.631 kPa for the left PT. Both PT volumes were found to be 1.6 ± 0.9 mm^3. There was no significant correlation between the SWE values obtained and age, height, weight, and BMI. Tonsil dimensions show a positive correlation with age, height, weight, and BMI. **Conclusion:** PT dimensions have a positive correlation with age, height, weight, and BMI, but not with SWE values. SWE may be a reliable diagnostic criterion independent of anthropometric values.

Keywords: Child, palatine tonsil, shear-wave elastography, ultrasonography

Introduction

Palatine tonsils (PTs) are an important tissue in the oropharynx, located between the palatopharyngeal arch and the palatoglossal arch, and play an important role in providing immunity to the body.[1]

During the embryological period, PTs are formed from endoderm cells of the 2nd pharyngeal sac. The tonsils enlarge and reach their final volume depending on the amount of lymphoid tissue present after birth.[2]

Tonsillitis is the most common inflammatory pathology associated with the PTs, and it is most commonly seen in children aged 6–12 years. Another pathology is peritonsillar abscess, which can rupture suddenly and obstruct the airway, posing a life-threatening situation. As a result of aspiration, it can spread to the mediastinum and cause mediastinitis or sepsis.[3,4]

Hypertrophy of the PTs can result in obstructive sleep apnea. Hypertrophic PTs account for 1%–5% of obstructive sleep apnea causes, particularly in children.[5,6]

Pathologies of the PT are frequently evaluated using magnetic resonance imaging (MRI) and computed tomography (CT). These methods, however, have drawbacks such as the need for sedation for MRI and exposure to ionizing radiation for CT.[7] Furthermore, these methods are not cost-effective. Ultrasonography (US) is increasingly being used to investigate PT pathologies and tonsil morphology.[8,9]

Shear-wave elastography (SWE) can assess the stiffness of any tissue noninvasively. SWE is a practical technique due to its low operator dependence and ease of application, particularly in the pediatric age group.[10] Understanding the stiffness (elasticity) value of any tissue is critical for diagnosis. Previous research on the neck region has shown that elastography values rise in thyroid cancer, lymph node cancer, and infections such as lymphadenitis.[11-15] There is

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only one study on PT SWE values in the pediatric age group in the literature.[7]

The goal of this study was to use the SWE method to determine the normal elasticity values of the PTs.

Materials and Methods

The current prospective study has been approved by the ethics committee of Erzincan Binali Yıldırım University Faculty of Medicine (approval number: ebyu-kaek-20200211). All participants and their parents provided informed consent. Data for the study were collected between January and April of 2021.

We included children who did not have a clinical diagnosis of tonsillar inflammation and upper respiratory disease (snoring and sleep apnea syndrome). We also excluded those who had recently received treatment for tonsillar inflammation (earlier than 2 weeks after the examination). The size of the tonsils of the children was not evaluated in the physical examination. Patients with immunodeficiency, cancer, autoimmune disease, or any rheumatological disease that could affect the tonsils were also excluded. Patients who were outside of the normal growth curve were also excluded. The study excluded 17 children who did not meet these criteria. The study included 122 healthy children in total.

Patients were divided into six subgroups based on their age, and the following analyses were performed for these subgroups: (1) 1–4 years, (2) 4–7 years, (3) 7–10 years, (4) 10–13 years, (5) 13–16 years, and (6) 16–18 years.

High-frequency linear-array transducers (4–12 MHz) in the longitudinal (Long.) and transverse (Tr.) planes were used to perform US examinations. (Affiniti 70G Philips Healthcare, Best, the Netherlands). The same transducer was used in all age groups.

The examinations were carried out in a supine position with no sedation. We located the tonsils by placing the transducer beneath the mandible. We discovered the submandibular gland first, followed by the tonsil, which is located just deep to the gland. Tonsil sizes were measured in the anteroposterior (AP), Tr., and Long. planes for both the right and left tonsils [Figure 1]. The volume of tonsils was calculated automatically by the US device using three plain measurements. Tonsil elastography values were determined automatically by the device's SWE feature [Figure 2]. One cm² region of interest (ROI) was used for elastography measurements.

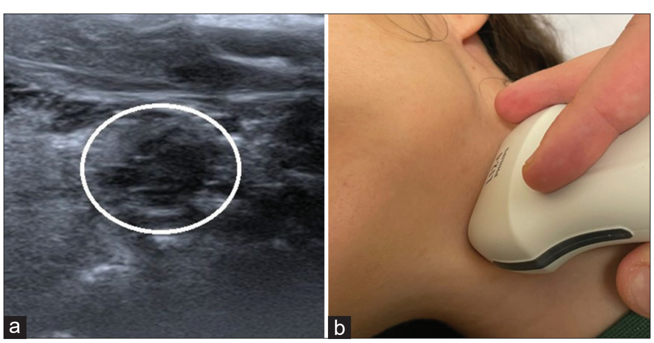

Figure 1: USG image obtained from the left palatine tonsil of a 17-year-old female patient using a linear transducer. Palatine tonsil (white circle) is hypoechoic compared to the surrounding tissues, and hyperechoic linear areas are observed in its parenchyma. (a) Body landmark (b). USG: Ultrasonography

During ultrasonographic imaging, care was taken to avoid applying pressure to the probe and to keep the practitioner's hand fixed. Each tonsil's size and elasticity were measured three times by two different observers, and the average of these measurements was recorded as the final data. Elasticity is measured in kilopascals.

The patients' age, gender, body mass index (BMI), height, and weight were all recorded to look for possible correlations between these parameters and tonsil dimensions and SWE values.

Statistical analysis

The data were analyzed using the SPSS package for social sciences (version 20) for Windows (IBM SPSS Inc., Chicago, IL, USA). The Kolmogorov–Smirnov test was used to determine whether the data had a normal distribution. Numerical variables with a normal distribution are reported as mean ± standard deviation, while variables with a nonnormal distribution are reported as medians with minimum and maximum values. Numbers and percentages are used to report categorical variables. Mann–Whitney *U* and Kruskal–Wallis tests were used to compare groups. The Mann–Whitney *U* test was used to compare the parameters based on gender. The Wilcoxon test was used to compare the parameters on the right and left sides. Spearman correlation analysis was used to identify potential relationships between tonsil dimensions/elasticity and age, gender, height, and weight values. Cohen's kappa coefficient was used to determine inter-rater agreement. Kappa values (k) of agreement were defined as poor between 0.01 and 0.20, fair between 0.21 and 0.40, moderate between 0.41 and 0.60, substantial between 0.61 and 0.80, and nearly perfect between 0.81 and 1.0.[16]

A two-tailed value of $P < 0.05$ was considered statistically significant.

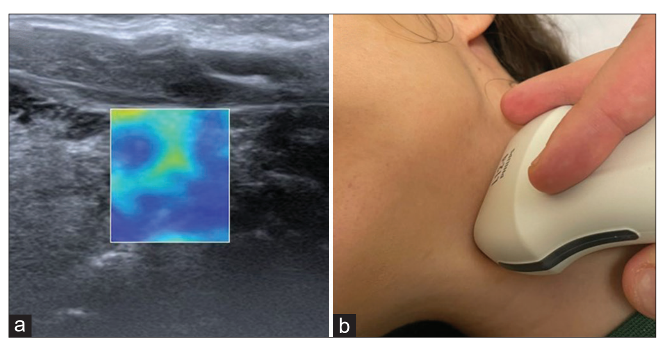

Figure 2: SWE elastography image obtained from the left palatine tonsil of a 17-year-old female patient using a linear transducer. (a) Body landmark (b). SWE: Shear-wave elastography

Results

The study included 122 children. In total, 54 (44.3%) of the children were male, while 68 (55.7%) were female. The median age of the entire population was 11 years (min-max; 1–18 years); the mean age of the entire population was 10.77 ± 4.35 years.

Tables 1 and 2 show the normal values for PT measurements based on age subgroups.

Table 3 shows the normal elastography values for the PT based on age subgroups.

PT measurements and volume did not differ by gender or side; median/mean AP, Tr., and Long. were all the same. PT diameters and volumes were comparable in boys and girls ($P = 0.72$), as well as on the right and left sides ($P = 0.81$). Tonsil sizes were found to be positively related to age, height, weight, and BMI [Table 4].

Age, gender, tonsil dimensions, height, weight, and BMI do not correlate with elastography values [Table 5].

Inter-rater agreement was substantial for size and elasticity measurements for both tonsils ($k = 0.71$ and 0.62, accordingly).

Discussion

PT's normal size, volume, and SWE values were determined in healthy children aged 1–18 years in our study. These values are classified based on age and gender. These values are useful

Table 1: Values for the right palatine tonsil

Age (years)	Patient number (%)	Median (minimum-maximum), mean±SD			
		PT diameters (mm)			PT volume (cm³)
		AP	Tr.	Long.	
1-4	8 (6.55)	11 (9-14), 11.25±1.909	13.50 (7-19), 13.25±5.258	16.1 (12.7-27.5), 16.9±3.3	1.3 (0.3-4.1), 1.5±0.75
4-7	28 (22.95)	12 (8-18), 12.14±2.877	11.50 (9-18), 11.93±2.595	16.5 (6-33), 17.5±5.1	1.3 (0.3-5.2), 1.7±1.02
7-10	24 (19.67)	13 (11-19), 13.92±2.448	12.50 (9-19), 12.25±2.609	15.8 (9-26), 16.9±4.3	1.2 (0.4-3.2), 1.5±0.7
10-13	22 (18.03)	12 (9-23), 13.36±4.238	15 (10-18), 14.09±2.810	19.2 (13.4-26.6), 19.1±3.7	1.9 (0.6-3.4), 2.0±0.65
13-16	26 (21.31)	13 (9-26), 14±4.418	11 (7-19), 12.62±3.848	18.9 (14-23), 18.8±2.6	1.8 (0.9-2.5), 1.6±0.8
16-18	14 (11.47)	12 (11-26), 14.86±5.390	16 (10-22), 15.86±3.780	19.1 (12.9-26.2), 18.9±3.1	2 (1-2.4), 2.1±0.5
Whole population	122	12 (8-26), 13.36±3.810	12 (7-22), 13.07±3.454	16.2 (6-33), 17.2±4.8	1.3 (0.3-5.2), 1.6±0.9

PT: Palatine tonsil, SD: Standard deviation, AP: Anteroposterior, Tr.: Transverse, Long.: Longitudinal

Table 2: Values for the left palatine tonsil

Age (years)	Patient number (%)	Median (minimum-maximum), mean±SD			
		PT diameters (mm)			PT volume (cm³)
		AP	Tr.	Long.	
1-4	8 (6.55)	11 (9-14), 11.25±1.909	13.50 (7-19), 13.25±5.258	16.1 (12.7-27.5), 16.9±3.3	1.3 (0.3-4.1), 1.5±0.75
4-7	28 (22.95)	12 (8-18), 12.14±2.877	11.50 (9-18), 11.93±2.595	16.5 (6-33), 17.5±5.1	1.3 (0.3-5.2), 1.7±1.02
7-10	24 (19.67)	13 (11-19), 13.92±2.448	12.50 (9-19), 12.25±2.609	15.8 (9-26), 16.9±4.3	1.2 (0.4-3.2), 1.5±0.7
10-13	22 (18.03)	12 (9-23), 13.36±4.238	15 (10-18), 14.09±2.810	19.2 (13.4-26.6), 19.1±3.7	1.9 (0.6-3.4), 2.0±0.65
13-16	26 (21.31)	13 (9-26), 14±4.418	11 (7-19), 12,62±3,848	18.9 (14-23), 18.8±2.6	1.8 (0.9-2.5), 1.6±0.8
16-18	14 (11.47)	12 (11-26), 14.86±5.390	16 (10-22), 15.86±3.780	19.1 (12.9-26.2), 18.9±3.1	2 (1-2.4), 2.1±0.5
Whole population	122	12 (8-26), 13.36±3.810	12 (7-22), 13.07±3.454	16.2 (6-33), 17.2±4.8	1.3 (0.3-5.2), 1.6±0.9

PT: Palatine tonsil, SD: Standard deviation, AP: Anteroposterior, Tr.: Transverse, Long.: Longitudinal

Table 3: Palatine tonsil normal elastography values

Age (years)	Median (minimum-maximum), mean±SD		
	Patient number (%)	Right PT elastography value (kPa)	Left PT elastography value (kPa)
1-4	8 (6.55)	10 (7-12), 9.75±2.053	11.50 (9-16), 12.00±2.928
4-7	28 (22.95)	11 (5-17), 10.71±3.065	8.50 (5-12), 8.50±2.169
7-10	24 (19.67)	10 (5-15), 9.58±2.552	9 (3-12), 8.58±2.552
10-13	22 (18.03)	9 (6-13), 9±2.093	10 (8-15), 10.55±2.283
13-16	26 (21.31)	11 (6-14), 10.38±2.351	10 (5-15), 9.77±2.438
16-18	14 (11.47)	9 (7-12), 9.29±1.729	10 (7-15), 10.14±2.958
Whole population	122	10 (5-17), 9.89±2.494	10 (3-16), 9.57±2.631

PT: Palatine tonsil, SD: Standard deviation

Table 4: Correlations between tonsil volume values and age, height, weight, and body mass index

Correlations (*r*/*P* values)	Volume (*P*)
Age	0.87 (0.001)
Height	0.76 (0.03)
Weight	0.66 (0.02)
BMI	0.88 (0.001)

BMI: Body mass index

Table 5: Correlations between palatine tonsil values and anthropometric parameters

Correlations (*r*/*P* values)	Elasticity
Gender	0.12 (0.17)
Weight	0.22 (0.25)
Height	0.32 (0.31)
BMI	0.11 (0.51)
Tonsil volume	0.03 (0.67)

BMI: Body mass index

because they can be used as a reference in PT pathologies. According to our findings, PT's size and volume were related to age, height, weight, and BMI, but elastography values were not.

The use of ultrasonography (USG) in PT pathologies is increasing, particularly in pediatric patients. In the evaluation of tonsils, USG is not the primary imaging method. Because CT and MR have limitations, ultrasound is a good supplement at this point. USG is less difficult to perform than CT and MR and can be easily repeated in follow-ups.[12,17] Ultrasound is also advantageous, because it is simple, noninvasive, and inexpensive, and it can be performed at the patient's bedside.[18] Furthermore, previous research found that USG was effective in the evaluation of tonsils, and the volume measurement results were correlated with actual values.[12,14-19]

There have been few studies on the normal dimensions and volume of PTs.[1-22] In our study, the right and left PT volumes were 1.6 ± 0.9 mm^3 and 1.6 ± 0.6 mm^3. The results are similar to our findings in the studies of Aydin and Uner,[1] Hosokawa *et al*.,[21] and Hong *et al*.[20] Tonsillar volumes were measured as 1.8 mm^3 in Öztürk's study,[22] which was found to be slightly higher than in our study. This was thought to be due to the positive correlation between PT dimensions and age, as well as the fact that Ozturk worked with a larger age population.

In our study, no difference in PT dimensions was found based on gender or right–left difference, as in previous studies.[20-22] The difference in two-sided tonsil dimensions can be interpreted as a red flag for potential pathology. Furthermore, it would be more accurate to disregard the gender during the US tonsil examination.

Tonsil dimensions show a positive correlation with weight, height, and BMI when the results are analyzed. These findings are consistent with the previous research.[1,21,22] Hong *et al*.[20] reported conflicting findings and found no significant correlation between height and weight. In our study, we discovered that BMI had the strongest correlation with tonsil dimensions. Weight and height with age are more important than gender and side in the evaluation of the PT.

Ultrasound elastography is a method for measuring tissue elasticity that provides quantitative and qualitative data about tissue elasticity in a practical manner. It has begun to be preferred over SWE strain elastography and acoustic radiation force impulse techniques due to its less reliance on the operator and ease of application. Tissue elasticity values can aid in the diagnosis and treatment of a variety of diseases. Understanding normal elastography values may aid in the detection of pathological changes in organs.[7] When our results were analyzed, we discovered that the right and left PT elastography values were 9.89 ± 2.494 kPa and 9.57 ± 2.631 kPa, respectively. Similar to our study, the results of Öztürk *et al*.[7] were 9.38 kPa and 9.57 kPa for the right and left PTs, respectively. This demonstrates that these findings can be used as normal reference values in PT pathology evaluations. Since elastography is an inexpensive, easily accessible, and radiation-free test, it can be used in the diagnosis of tonsillar diseases in children.

There was no correlation found between SWE values obtained through ultrasound elastography and gender, height, or weight values. The lack of correlation between SWE values and these parameters indicates that SWE has the potential to be a reliable evaluation criterion independent of anthropometric values. In addition, significant interobserver agreement for SWE measurements can augment the diagnostic utility of PT elastography.

Our research has some limitations. Working with a larger population and homogenizing age subgroups could yield better results. Group 1 consists of all male patients. Equal evaluation of male and female patients in this age group may improve the results. Since we have recorded the mean value of the measurements, we could not provide intrarater agreement data.

Conclusion

PT dimensions have a positive correlation with age, height, weight, and BMI, but not with SWE values. SWE may be a reliable diagnostic criterion independent of anthropometric values due to the lack of correlation between SWE values and specified parameters.

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Conflicts of interest

There are no conflicts of interest.

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