Evaluation of Parotid Glands With Real-time Ultrasound Elastography in Children

Gulay Gungor, MD, Nursel Yurttan, MD, Nagihan Bilal, MD, Mehmet Sait Menzicioglu, MD, Mahmut Duymus, MD, Serhat Avcu, MD, Serdal Citil, MD

Objectives—The aim of this study was to determine the strain index for parotid glands in children by using ultrasound elastography.

Methods—In this prospective study, apparently healthy children were referred from the ear-nose-throat clinic to the radiology clinic for elastographic examinations. Conventional sonographic and elastographic examinations of the parotid glands were performed. A linear 5–12-MHz transducer was used to obtain the images.

Results—A total of 54 children were enrolled in this prospective study. The normal mean strain index value ± SD for the parotid glands was 1.24 ± 0.67 (range, 0.29–1.39) regardless of sex. The mean age of girls was 7.42 ± 2.94 years (range, 3–14 years), and the age of boys was 8.50 ± 3.46 years (range, 4–16 years). The strain index values for the parotid glands in boys was 1.25 ± 0.76, and in girls it was 1.22 ± 0.55. There was no statistically significant difference in the strain index values between girls and boys ($P = .986$). There was no correlation between the strain index and age ($r = 0.026$) or body mass index ($r = 0.066$).

Conclusions—This study determined the mean strain index values for apparently healthy children. Such information can serve as a baseline from which pathologic parotid diseases can be diagnosed with ultrasound elastography in combination with other sonographic criteria.

Key Words—children; parotid; pediatric ultrasound; strain index ratio; ultrasound elastography

Received March 30, 2015, from the Clinics of Radiology (G.G., S.C.) and Ear-Nose-Throat (N.B.), Kahramanmaras Necip Fazıl City Hospital, Kahramanmaras, Turkey; Department of Radiology, Kahramanmaras University School of Medicine, Kahramanmaras, Turkey (N.Y.); and Department of Radiology, Gazi University School of Medicine, Ankara, Turkey (M.S.M., M.D., S.A.). Revision requested May 12, 2015. Revised manuscript accepted for publication July 23, 2015.

Address correspondence to Mehmet Sait Menzicioglu, MD, Department of Radiology, Gazi University School of Medicine, Beşevler, 06100 Ankara, Turkey.

E-mail: dr.m.sait@hotmail.com

Abbreviations
BMI, body mass index; ROI, region of interest

doi:10.7863/ultra.15.03073

The parotid gland, which is the largest of all salivary glands, is located in the parotid space and composed of glandular and adipose tissues in almost equal amounts.[1] The parotid gland secretes saliva through the parotid duct into the oral cavity to facilitate mastication and swallowing. The most common initial diagnostic method for evaluation of morphologic and structural changes in the parotid gland is grayscale sonography, based on its high availability, relatively low cost, and adequate level of accuracy in confirming a clinical diagnosis and directing further examinations. Since sonography does not involve radiation, it is considered the most appropriate initial examination for children and pregnant women.[2,3] The limitations of sonography include difficulties in visualizing deep lesions, as well as any extensions of these lesions into the retropharyngeal and parapharyngeal spaces, the base of skull, and the deep cervical lymph chain.[4]

Ultrasound elastography is a recently developed imaging procedure that is able to map the elastic characteristics of soft tissues.[5] When compressed, stiff tissue displays less compressibility, as well as less strain and deformation, than soft tissue.[6] Based on the palpation principle, elastography was initially designed to identify stiffer masses such as tumors located inside normal tissues, and the procedure has been proven useful for noninvasive differentiation of benign and malignant lesions in multiple organs. Strain elastography and shear wave elastography are the two main methods used when performing an elastography procedure, with the former being more common.[7–10] Tissue elasticity is estimated by measuring the local displacements in ultrasonic signals before and after the application of a compressive force.[6] Strain elastography is an operator-dependent technique, and training and experience are of great importance. Parameters influencing image quality in strain elastography are window width, compression velocity, and force applied on the probe. In this technique, the probe movements must be toward the same direction; the palpation frequency must be regular; and the window width must be localized to an examination area.[11,12]

Although elastography has been used for examination of certain parotid gland diseases, there have been no previous evaluations of normal parotid gland elasticity in healthy children. In this study, we determined the mean values of parotid gland elasticity and stiffness in healthy children, which might serve as a basis for further studies related to other parotid gland abnormalities.

Materials and Methods

Informed consent was obtained from the parents of all children enrolled in the study, and Ethics Committee approval was obtained from Sutcu Imam University. This prospective study consisted of 54 healthy children (26 girls and 28 boys) whose parents were informed about the study. The inclusion criteria were absence of having any parotid gland disorder (ie, inflammation, mass, or lymphoma) and systemic disease affecting the parotid gland (ie, Sjögren syndrome or lymphoma) at the time of the study and no history of parotid gland disorders. Exclusion criteria were infectious, autoimmune, and inflammatory parotid gland disorders and malignancies involving the parotid glands. Since the elastographic examination could not be performed optimally in children younger than 3 years, those children were not included in our study.

Healthy children were referred from the ear-nose-throat clinic to the radiology clinic for elastographic examinations. In the ear-nose-throat clinic, the histories and physical examinations of the children were reviewed for their current status and history of parotid or systemic diseases, and then the children underwent elastographic examinations in the radiology clinic by a radiologist with 4 years of experience in elastography. All of the elastographic examinations were performed by the same radiologist on the superficial part of the parotid gland, avoiding any lymph node or vascular structure.

Conventional sonographic examinations were performed with a HI VISION Preirus ultrasound device (Hitachi Medical Systems, Tokyo, Japan). A linear 5–12-MHz transducer was used to obtain the images. Routine B-mode grayscale sonography was performed before elastography. The elastographic mode was activated by using the "elast" button. The monitor was divided into 3 parts as right, left, and bottom parts. The right part showed the routine grayscale image; the left part showed the elastogram, and the bottom part showed the pressure wave. To obtain elastograms and data, the transducer was used by making regular and slight compressions and decompressions (Figures 1 and 2) that could be followed by the sinusoidal wave at the bottom of the screen. After approximately 10 to 12 regular waves were obtained, the image was frozen for measurements. After freezing, we used region of interest (ROI) circles (4 mm in diameter) to measure the strain index of the parotid glands. We used 2 ROIs: a reference ROI that we fixed to the superficial portion of the normal parotid gland parenchyma and another that was fixed to the adjacent soft tissue. Measurements were done in the decompression phase, which was below the baseline. The elastographic software presented a semiquantitative value as a numeric strain ratio. Three measurements were obtained for each (right and left) parotid gland, and the mean value was used for statistics.

SPSS version 21 software (IBM Corporation, Armonk, NY) was used for statistical analysis. Continuous variables were expressed as arithmetic mean ± standard deviation. $P < .05$ was considered statistically significant. A 1-sample Kolmogorov-Smirnov test and Q-Q plot charts were was used to determine the distribution of the parameters. A Student t test was performed to determine the differences between strain ratios for boys and girls. Pearson correlation was used to determine the correlations. With an effect size of 0.7 and a sample size of 26 participants in each group, the study power was estimated at 80%. Thus, 28 boys and 26 girls were recruited for this study. Related calculations were made with the G*Power version 3.0.8 software (Heinrich-Heine University of Düsseldorf, Düsseldorf, Germany).

Results

The mean age of girls was 7.42 ± 2.94 years (range, 3–14 years), and the age of boys was 8.50 ± 3.46 years (range, 4–16 years). All of the children had apparently healthy parotid glands, and there were no exclusions. Adequate data were acquired from all children. There was neither any significant difference in stiffness measurements within the 3 measurements taken per gland nor any difference between the right versus left side.

The mean strain index value in our study was 1.24 ± 0.67 (range, 0.29–1.39) regardless of age and sex (Table 1 and Figure 3). There was no statistically significance between the age, sex, weight, height, body mass index (BMI), and strain index of the girls and boys (Tables 2 and 3 and Figure 4). The strain index value for the parotid gland in boys was 1.25 ± 0.76, and in girls it was 1.22 ± 0.55. There was no statistically significant difference between boys and girls (Table 3 and Figure 5). There was no correlation between the strain index and age or between the strain index and BMI (Table 4).

Figure 1. Elastogram of the parotid gland. The monitor is divided into 3 windows: The right window is a gray scale sonogram; the left window is a color-coded elastogram; and the bottom window is sinusoidal wave of compression and decompression. The circles indicate the ROIs: the bottom ROI is on the parotid gland; and the top ROI is on the adjacent tissue. The vertical line on the sinusoidal wave indicates the point of measurement.

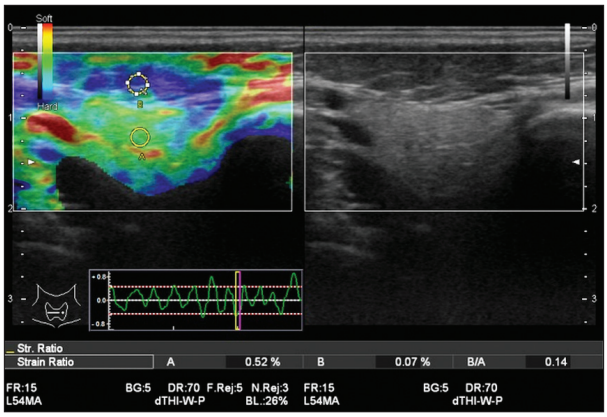
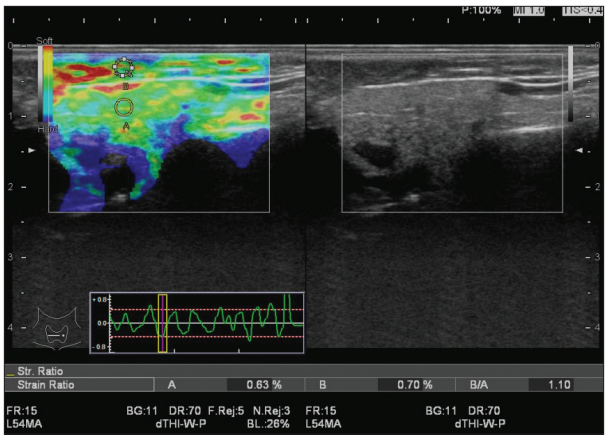


Figure 2. Elastogram of the parotid gland. Notations are as in Figure 1.



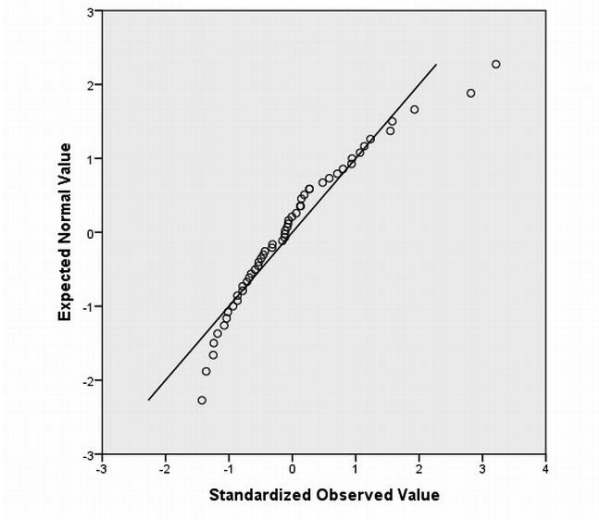
Discussion

Sonography is an effective and reliable method for diagnosis of salivary gland diseases, providing detailed information regarding the size, shape, and echogenicity of lesions, as well as their acoustic effects and relationship with circumjacent tissue.[13] On sonography, the parotid gland has usually a more homogeneous and hyperechoic appearance than the adjacent muscle tissue. The echogenicity of the parotid gland is determined by the amount of intraglandular fat tissue.

Table 1. Descriptive Values for Age, Height, Weight, BMI, and Strain Index Regardless of Sex

Parameter	Minimum	Maximum	Mean	SD
Age, y	3.00	16.00	7.98	3.24
Height, cm	93.00	169.00	127.57	17.92
Weight, kg	12.00	69.00	28.94	12.77
BMI, kg/m^2	13.40	25.00	16.91	2.82
Strain index	0.29	3.39	1.24	0.67

Figure 3. Distribution of parotid gland strain index values regardless of age and sex. The distribution is normal.



Ultrasound elastography is different from other anatomic imaging techniques, in that tissue contrast is obtained through relative differences in mechanical stiffness. The technique uses deformities resulting from external compression for imaging and is hence dependent on the person performing the examination, which may lead to potential variations in the results of examiners using this procedure. Differences between the elastic properties of pathologic and normal tissues form the basis of the elastographic approach for detection of malignant lesions, especially during breast imaging; however, elastography can also be used to evaluate the overall elasticity of tissue and so can be used for imaging of the salivary glands.[7]

In general, diseases of the salivary glands are uncommon in infants and children, with most being of vascular or inflammatory origin.[14,15] Inflammation of the salivary glands can be shown by detecting parenchymal changes on elastography, which can provide information on different parotid inflammatory processes and may also serve as a useful tool for evaluation of the parotid during chronic inflammations.[16]

In our study, we demonstrated that boys and girls had similar parotid gland stiffness values. Also, the stiffness values did not show any difference between the age, BMI, weight, and height of boys and girls. There was no change in stiffness based on age and BMI. These findings can make it easy

Table 2. Height, Weight, and BMI of Boys and Girls

Parameter	Minimum	Maximum	Mean	SD
Boys				
Height, cm	104.00	169.00	130.43	17.91
Weight, kg	15.00	65.00	31.21	13.05
BMI, kg/m^2	13.80	23.60	17.39	2.66
Girls				
Height, cm	93.00	166.00	124.50	17.76
Weight, kg	12.00	69.00	26.50	12.29
BMI, kg/m^2	13.40	25.00	16.40	2.95

Table 3. Student *t* Test Results for Girls and Boys (Equal Strain Index Variances Assumed)

Parameter	Value
t	0.194
Mean difference	0.036
SE difference	0.190
95% CI of difference	–0.330 to 0.400
P	.847

CI indicates confidence interval.

Figure 4. Strain index (P) values according to age group. We pooled the participants in 3 age groups for this graphic.

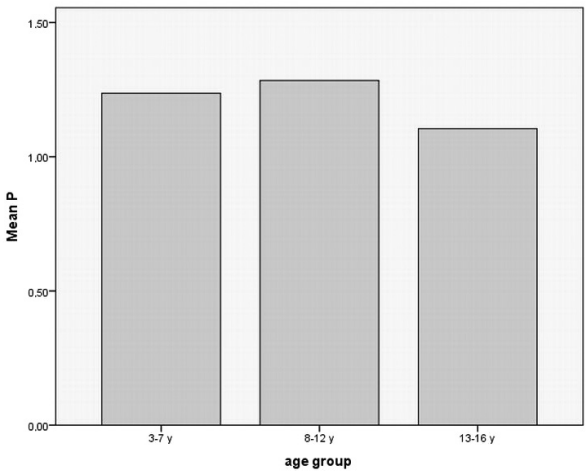


Figure 5. Strain index (P) values according to sex. Top and bottom lines indicate higher and lower values; and dots indicate excessive values.

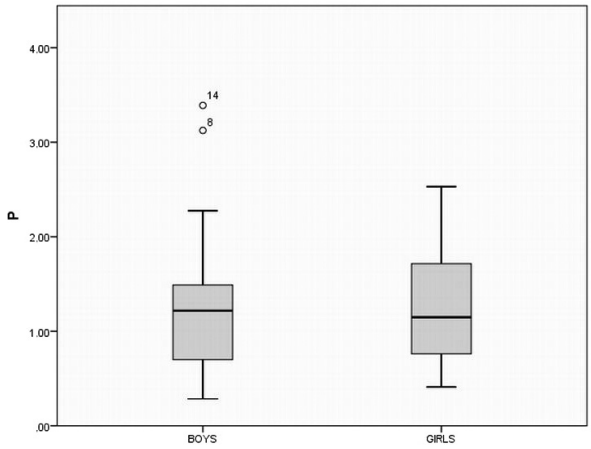


Table 4. Correlations of Strain Index With Age and BMI

Parameter	Value
Age	
Pearson *r*	0.026
P	.854
BMI	
Pearson *r*	0.066
P	.636

to use a single value for both sexes. This value can be useful for children of all ages, weights, heights, and BMIs. It is not necessary to use different mean values for parameters such as BMI and sex. The reason for the stability in stiffness values in the parotid gland may be related to the lack of substantial changes in its tissue components according to sex, age, weight, and height, as shown in our study population. The abnormal stiffness values in children of all ages and both sexes may shed light on parotid gland diseases.

The major limitation of our study was the inability to detect smaller variations in strain index values because of the limited sample size.

To the best of our knowledge, there is no published article about normal parenchymal strain index values for the parotid gland in children. The mean strain index value was 1.24 ± 0.67 in our study. We think that this threshold value can assist the user in having an idea about the normal parotid gland and parotid diseases while performing elastography.

In conclusion, this study determined the normal elasticity of parotid glands by displaying a mean strain index value, which was not affected by the age, sex, or BMI of the apparently healthy children in our study population. Thus, our study can serve as a baseline and reference for upcoming studies of the diagnosis of parotid diseases.

References

1. Rastogi R, Bhargava S, Mallarajapatna GJ, Singh SK. Pictorial essay: salivary gland imaging. *Indian J Radiol Imaging* 2012; 22:325–333.
2. Badea AF, Bran S, Tamas-Szora A, Floareş A, Badea R, Baciut G. Solid parotid tumors: an individual and integrative analysis of various ultrasonographic criteria—a prospective and observational study. *Med Ultrason* 2013; 15:289–298.
3. Grazioli L, Olivetti L, Matricardi L, et al. Comparison of ultrasonography, computerized tomography, and magnetic resonance in the study of parotid masses [in Italian]. *Radiol Med* 1993; 86:268–280.
4. Izzo L, Casullo A, Caputo M, et al. Space-occupying lesions of parotid gland: comparative diagnostic imaging and pathological analysis of echo color/power Doppler and of magnetic resonance imaging. *Acta Otorhinolaryngol Ital* 2006; 26:147–153.
5. Klintworth N, Mantsopoulos K, Zenk J, Psychogios G, Iro H, Bozzato A. Sonoelastography of parotid gland tumours: initial experience and identification of characteristic patterns. *Eur Radiol* 2012; 22:947–956.
6. Bhatia KS, Rasalkar DD, Lee YP, et al. Evaluation of real-time qualitative sonoelastography of focal lesions in the parotid and submandibular glands: applications and limitations. *Eur Radiol* 2010; 20:1958–1964.
7. Berko NS, Fitzgerald EF, Amaral TD, Payares M, Levin TL. Ultrasound elastography in children: establishing the normal range of muscle elasticity. *Pediatr Radiol* 2014; 44:158–163.
8. Gietka-Czernel M, Kochman M, Bujalska K, Stachlewska-Nasfeter E, Zgliczyński W. Real-time ultrasound elastography: a new tool for diagnosing thyroid nodules. *Endokrynol Pol* 2010; 61:652–657.
9. Wierzbicka M, Kałużny J, Szczepanek-Parulska E, et al. Is sonoelastography a helpful method for evaluation of parotid tumors? *Eur Arch Otorhinolaryngol* 2013; 270:2101–2107.
10. Yerli H, Eski E, Korucuk E, Kaskati T, Agildere AM. Sonoelastographic qualitative analysis for management of salivary gland masses. *J Ultrasound Med* 2012; 31:1083–1089.
11. Doyley MM, Bamber JC, Fuechsel F, Bush NL. A freehand elastographic imaging approach for clinical breast imaging: system development and performance evaluation. *Ultrasound Med Biol* 2001; 27:1347–1357.
12. Havre RF, Elde E, Gilja OH, et al. Freehand real-time elastography: impact of scanning parameters on image quality and in vitro intra- and interobserver validations. *Ultrasound Med Biol* 2008; 34:1638–1650.
13. Knopf A, Mansour N, Chaker A, Bas M, Stock K. Multimodal ultrasonographic characterisation of parotid gland lesions: a pilot study. *Eur J Radiol* 2012; 81:3300–3305.
14. Ellies M, Laskawi R. Diseases of the salivary glands in infants and adolescents. *Head Face Med* 2010; 6:1.
15. Lee YY, Wong KT, King AD, Ahuja AT. Imaging of salivary gland tumours. *Eur J Radiol* 2008; 66:419–436.
16. Wierzbicka M, Kałużny J, Ruchała M, Stajgis M, Kopeć T, Szyfter W. Sonoelastography: a useful adjunct for parotid gland ultrasound assessment in patients suffering from chronic inflammation. *Med Sci Monit* 2014; 20:2311–2317.