Original Article

http://dergipark.org.tr/en/pub/anatomy
Received: December 16, 2021; Accepted: April 11, 2022
doi:10.2399/ana.21.9153256

anatomy
An International Journal of Experimental and Clinical Anatomy

Sonoelastography findings of the patellar tendon in Osgood-Schlatter disease

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Abstract

Objectives: There are ultrasonographic findings defined in Osgood-Schlatter disease. However, sonoelastographic findings of the disease have not been previously defined. The aim of this study was to evaluate the B-mode ultrasonography (US), Color Doppler ultrasonography (CDUS), and sonoelastography (SEL) findings of the patellar tendon in patients with Osgood-Schlatter disease (OSD) and compare it with healthy individuals.

Methods: A total of 36 patellar tendons were evaluated in 12 patients with OSD and 10 healthy individuals by US, CDUS, and SEL. Thickness, echogenicity, CDUS, and SEL findings of the distal patellar tendon in each group were evaluated.

Results: A total of 22 individuals (19 males, 3 females) and 36 tendons (9 with acute OSD, 7 with chronic OSD and 20 control healthy tendons) were included in this study. The patellar tendons were statistically significantly thicker in OSD patients in comparison with healthy volunteers (5.68±2.32 mm versus 3.42±0.55 mm) (p=0.001). According to the SEL evaluation, all of the patellar tendons in patients with OSD were of type 2 in contrast with all of the patellar tendons in healthy volunteers were of type 1 (p<0.001).

Conclusion: Distal patellar tendon in patients with OSD was thicker and softer in comparison with healthy volunteers. The intratendinous and/or peritendinous vascularity on CDUS was increased in patients with acute OSD. We suggest that these findings could be associated with tendon degeneration in OSD patients and can be useful in the evaluation of the disease.

Keywords: Osgood-Schlatter disease; patellar tendon; sonoelastography

Anatomy 2022;16(1):13–18

Introduction

Osgood-Schlatter disease (OSD) is commonly seen in active adolescents and widely accepted as a traction apophysitis of the tibial tuberosity.[1] Chronic repetitive traction trauma in the apophysial cartilage may cause epiphyseal enlargement and microruptures. This causes avulsion fractures, which are osteochondral fragmentations, and tendinopathy at the attachment site of the distal patellar tendon to the tibial tuberosity.[1,2] The typical presentation of OSD is pain and tenderness over the tibial tuberosity. The anamnesis and the physical examination of the patient are generally sufficient to make a diagnosis.[3] However, imaging modalities are commonly needed for the evaluation of tibial tuberosity and additional findings in OSD.[3] Along with technological development, the frequency of ultrasonography (US) usage for evaluation of the musculoskeletal system has enhanced over time and now is commonly used in daily practice.[4,5] US have low cost, easier use and accessibility, repeatability, no radiation exposure and it is applicable for all age groups. These features serve as important advantages of this modality.[6] Also, US takes less time and thus more tolerable for the patients when compared to magnetic resonance imaging (MRI) which makes the US the preferred radiological modality in the evaluation of tendons.[7] US evaluation can also provide information related to the size, extent, morphological feature of the lesion as well as vascularization of the lesion with color Doppler US (CDUS).

Recently, ultrasound elastography has become available for the assessment of soft tissue, in addition to the standard

B¬ mode US imaging and CDUS. The principle of sonoelastography (SEL) is based on the displacement of the tissues which depends on the stiffness of the tissue due to the applied compression. This displacement can be calculated and generated on a color map superimposed on the B-mode image.[8,9] On SEL, information about the stiffness of the lesions as well as tissues can be determined by coding in different colors that represent stiffness levels of the tissues.[10] The usage of SEL in the musculoskeletal system was limited in the past. However, this number is increasing with the extensive usage of US devices for this purpose.[11–13]

The US findings of OSD include thickened patellar tendon with pretibial swelling, fluid collection in the infrapatellar bursa, and fragmentation of the ossification center.[14,15] According to our knowledge, the SEL findings of OSD has not been previously defined. Therefore, in this study, we aimed to evaluate US, CDUS, and SEL findings of patellar tendons in patients with acute and chronic OSD in comparison with healthy individuals.

Materials and Methods

A total of 36 patellar tendons (9 patellar tendons of 7 patients with acute OSD, 7 patellar tendons of 5 patients with chronic OSD, and 20 patellar tendons of 10 healthy individuals) were evaluated. We included the diseased patellar tendons in the patient population and both patellar tendons in the healthy individuals. All acute OSD patients had knee pain and swelling. Chronic OSD was defined as having a history of tendon injury and OSD. Chronic OSD patients had typical US findings and were asymptomatic at the time of imaging. The control group consisted of individuals who were referred for a neck US, in the same age range as the study population, and did not have a history of knee injury or a clinical finding which indicated a tendon disorder. Additional informed consent was obtained from all patients for the identifying data included in the study. All procedures followed were in accordance with the ethical standards.

All patients with acute OSD, chronic OSD, and healthy volunteers underwent US, CDUS and SEL evaluation of the distal patellar tendon. The sonographic examinations were performed with a real-time scanner GE Logiq E9 (GE Healthcare, Milwaukee, Wisconsin, USA) and a linear array transducer with a frequency of 5–11 MHz or Toshiba Aplio 500 (Toshiba Medical Systems Corporation, Tochigi, Japan) with a 7–15 MHz wide-band linear transducer by the same experienced radiologist (M.B., with 11 years of experience in the musculoskeletal US). All patellar tendons were examined in axial and longitudinal planes in the sitting position with the knee at 30° flexion. The thickness of the tendon was determined by measuring the anteroposterior diameter of the distal patellar tendon in the distal adhesion site in a longitudinal view with B-mode sonography. Longitudinal plane was used for generation of real-time elastographic images of the tendon. Slight compression and decompression was applied for the calculation of local strain, and optimization of the strain was evaluated according to the visual indicator of compression that indicates the average strain in the region of interest between two frames. Real-time calculation was used for the tissue elasticity distribution and results were generated on a color map superimposed on the B-mode image. According to the color map, tissue's relative stiffness was represented as a spectrum ranging from blue (hard) to red (soft), blue – green indicated hard tissue, yellow indicated intermediate tissue, and red indicated soft tissue. Multiple real-time elastographic images of the distal part of each tendon was evaluated and the most representative one demonstrating the tendon boundary and peritendinous layers were chosen for image interpretation. This selection and image interpretation was performed by two radiologists (M.B. and I.S.I.) with consensus. Two main types including type 1; blue and green colors-hard tissue, and type 2; yellow and red within green colors-intermediate and soft tissue was defined. Beyond this definition, 2 subtypes of these types including type 1a; blue predominance, type 1b; green predominance, type 2a; small yellow and red areas within green predominance, and type 2b; green areas within yellow and red predominance were defined. Hereby, the elasticity of the tissue was shown as a spectrum ranging from hard to soft as the type progressed from 1a to 2b.[11]

The statistical analysis was made by SPSS (Statistical Package for Social Sciences) for Windows (Version 22, Chicago, IL, USA). Categorical data are presented as numbers (percentages), while continuous variables are expressed as mean±standard deviation and range. The normality of the variables was tested by the Shapiro-Wilk test. Categorical data were compared using the Pearson chi-square test/Fisher's exact test and continuous variables were compared using the Mann-Whitney U test. Kruskal-Wallis analysis was performed for comparing the difference in tendon thickness in patients with acute OSD, chronic OSD, and healthy individuals. The degree of association between continuous and ordinal variables was calculated by Spearman's rho coefficient. All tests were two-sided with a level of significance of $p<0.05$. For the power calculation of this study, post hoc power analysis (for p-value of <0.05, Cohen's D of 0.8 for a large effect, and total sample size of 36 for a 2-tailed hypothesis) demonstrated an observed power of 0.998.

Results

A total of 22 individuals (19 males, 3 females) and 36 tendons were included in this study. The mean age of the participants was 21.09± .98 years (range: 13–34 years). A total of 16 patellar tendons of 12 patients with OSD (11 males, 1 females) including 4 patients with both involved tendons and 20 patellar tendons of 10 individuals with no history of OSD or symptoms that formed healthy volunteer group (8 males, 2 females) were evaluated. Seven patients with 9 patellar tendons had symptomatic acute stage OSD disease, 5 patients with 7 patellar tendons had asymptomatic chronic stage OSD. The mean age of the OSD group was 23.25±7.79 years (range: 13–34 years), and the mean age of the healthy volunteers was 18.5±5.06 years (range: 13–25 years). There was no significant difference in terms of age (p=0.114) and gender (p=0.571) of OSD patients and healthy volunteers.

A total of 36 patellar tendons (19 right sides, 17 left sides) were evaluated. There was 9 right and 7 left tendons in the OSD group, and 10 right and 10 left tendons in the healthy volunteer group with no side predominance (p=0.709). All patellar tendons in patients with acute OSD (n=9) had low echogenicity with coarse calcification and increased intratendinous and/or peritendinous vascularity on CDUS. Cortical irregularities on tibial tuberosity and infrapatellar deep bursitis were also detected in patients with acute OSD. All patellar tendons in patients with chronic OSD (n=7) included microcalcifications. In this patient population, we did not observe increased intratendinous or peritendinous vascularity on CDUS.

The median tendon thickness of the OSD patients was 4.75 mm (range: 3.1–10.0 mm) and healthy volunteers were 3.3 mm (range: 2.5–4.2 mm). The tendons were statistically significantly thicker in OSD patients (p=0.001). The median tendon thickness was higher in the acute OSD patients (7.5 mm; range: 4.5–10.0 mm) and followed by chronic OSD (4 mm; range: 2.9–4.0 mm) and healthy volunteer group (3.3 mm; range 2.5–4.2 mm) (p<0.001) (**Figure 1**).

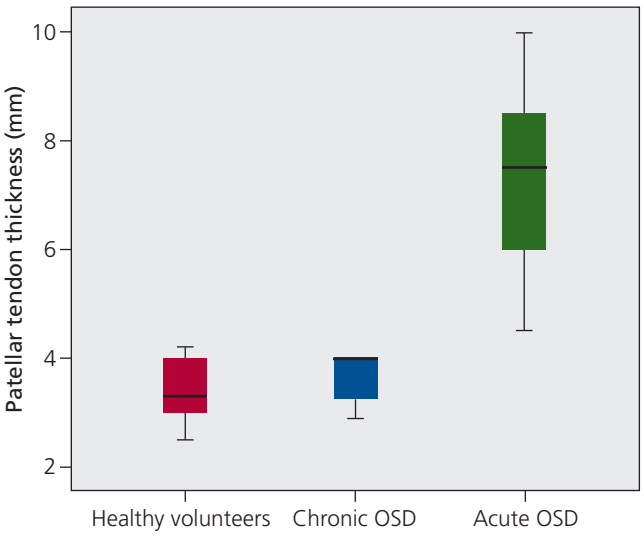

Figure 1. The boxplot shows the distal patellar tendon thickness in patients with acute OSD, chronic OSD, and healthy volunteers. **OSD:** Osgood-Schlatter disease.

SEL evaluation demonstrated that all of the patellar tendons in patients with OSD had a type 2 structure (16 of 16 tendons) and all of the patellar tendons in healthy volunteers had a type 1 structure (20 of 20 tendons) according to the main elastographic types with a statistically significant difference (p<0.001). The elastographic subtypes of the patients were as follows: most of the patellar tendons in patients with acute OSD were of type 2b (8 of 9 acute OSDs) (**Figure 2**) and 1 was of type 2a. All patellar tendons in patients with chronic OSD were of type 2a (**Figure 3**). All healthy volunteers had type 1a tendons (**Figure 4**). There were no type 1b patellar tendons. There were statistically significant differences in patients with

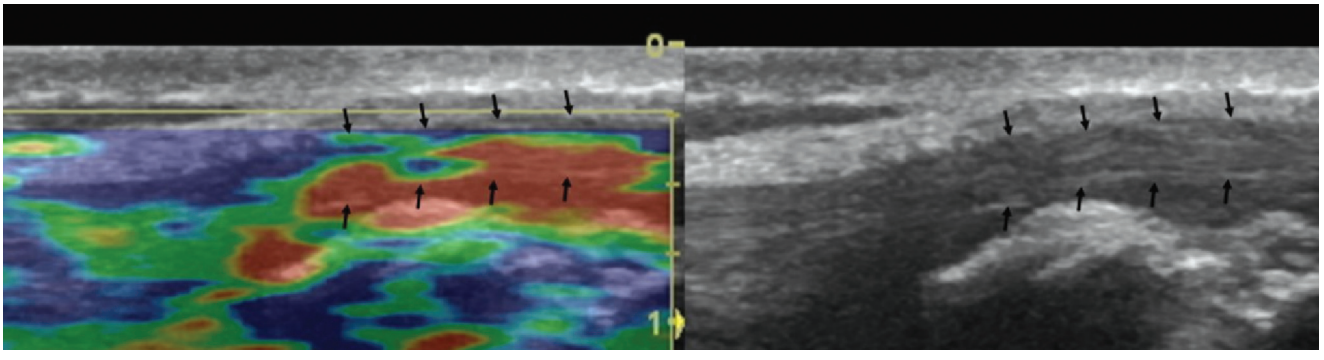

Figure 2. SEL evaluation of the patellar tendon (**arrows**) demonstrates a type 2b structure in a 15-year-old male patient with acute Osgood-Schlatter disease.

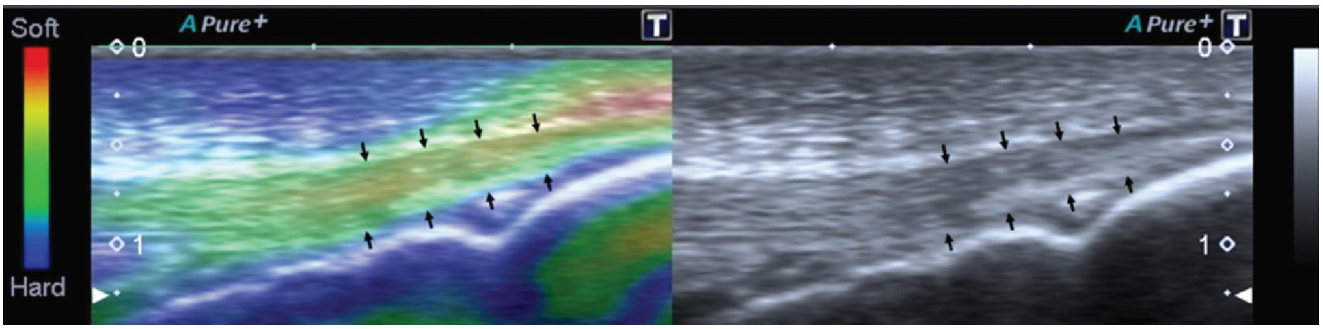

Figure 3. SEL evaluation of the patellar tendon (arrows) demonstrates a type 2a structure in a 30-year-old male patient with chronic Osgood-Schlatter disease.

and without OSD (p<0.001) and in patients with acute OSD, chronic OSD, and healthy volunteers (p<0.001) in terms of elastographic subtypes (**Table 1**). There was a significant positive correlation between tendon thickness and elastographic subtypes (rs=0.669, p<0.001).

Discussion

In this study, we evaluated US and SEL findings of patellar tendons in patients with OSD in comparison with healthy volunteers. We observed that patellar tendons are thicker in patients with OSD which is more obvious in tendons of patients with acute OSD. In the SEL evaluation of the patellar tendons, we observed that all tendons in patients with OSD were of type 2 and all patellar tendons in healthy individuals were of type 1 according to the main elastographic types. When we evaluated the elastographic subtypes, most of the patellar tendons in patients with acute OSD were of type 2b and all patellar tendons in patients with chronic OSD were of type 2a structure with a statistically significant difference in comparison with healthy volunteers.

The thick appearance of epiphyseal cartilage in the distal patellar tendon, cortical irregularities compatible with osteochondrosis, calcific fragmentations, decrease in tendon echogenicity consistent with degenerative changes, and accompanying infrapatellar bursitis are the main findings of OSD in B-mode US examination.[14] In the acute phase; local hyperemia is evaluated as a marked increase in vascularization by CDUS.[15] In our patient population, all patellar tendons in patients with acute OSD had low echogenicity compatible with the study of Blankstein et al.[14] We also observed increased tendon vascularity with CDUS. We also observed infrapatellar deep bursitis in patients with acute OSD. In previous studies, it was reported that healthy patellar tendon thickness is 3–3.5 mm in the middle section and 4–5 mm at the proximal and distal adhesion site.[15] According to the results of our study, the patellar tendons got thicker in patients with acute OSD when compared to healthy individuals. Likewise, our results showed that, the patellar tendon thickness of patients with acute OSD was statistically significantly higher in comparison with patients with chronic OSD and healthy individuals.

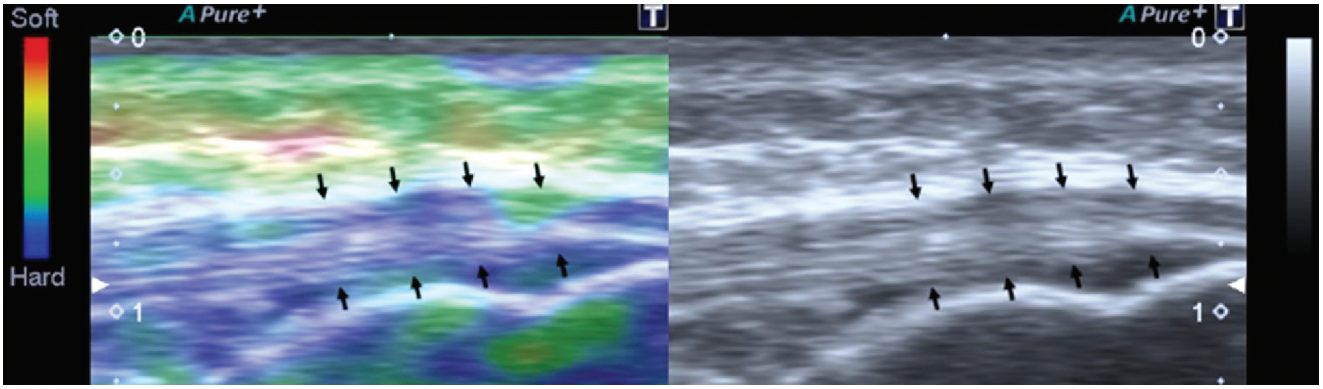

Figure 4. SEL evaluation of the patellar tendon (arrows) demonstrates a type 1a structure in a 14-year-old female healthy volunteer.

Table 1

B- mode US, CDUS and SEL characteristics of the distal patellar tendons in study population.

	Acute OSD (n=9)	Chronic OSD (n=7)	Healthy volunteers (n=20)
The average tendon thickness (mm) (median; range)	7.5; 4.5–10 mm	4; 2.9–4 mm	3.3; 2.5–4.2 mm
B-mod US findings			
Decrease in tendon echogenicity	+	-	-
Micro calcification	-	+	-
Coarse calcification	+	-	-
Cortical irregularities	+	-	-
Infrapatellar deep bursitis	+	-	-
CDUS findings			
Increased intratendinous and/or peritendinous vascularity	+	-	-
SEL subtypes	2b (n=8) 2a (n=1)	2a (n=7)	1a (n=20)

CDUS: color Doppler US; **OSD:** Osgood-Schlatter disease; **SEL:** sonoelastography; **US:** ultrasound.

Elastography is a new sonographic modality in which the elasticity of different tissue types is evaluated. The basic principle on which SEL is based is the strain (displacement) due to compression applied to viable tissue. This displacement can be calculated with the modified US and reflected on the color scale.[8,16,17] In our study, we observed a markedly soft appearance of the tendon in symptomatic OSD cases (coding in red color) and a moderately hard appearance (showing a yellow-red color coding in green) in the patients with chronic OSD. This is similar to the previous studies which evaluated SEL findings in tendinopathy. In a series of 214 patients whose clinical examination suggested tendinopathy or underwent surgical treatment but had no sonographic abnormality on the B-mode US, 164 patients had positive findings supporting tendinopathy in SEL.[18] Another study by Prado-Costa et al.[19] evaluated tendon damage in 26 cases with different tendons including patellar tendon and observed a decrease in the tendon stiffness in the presence of tendinopathy. In a study by Porta et al.,[20] it was emphasized that compression-based SEL examination is a useful and easily applicable method in the evaluation of patellar tendon in healthy subjects In this study, we found that SEL demonstrated hard coding in tendons of healthy individuals and soft coding in tendons with pathological changes. As a result, it was determined that small changes in the elasticity and mechanical characteristics of the distal patellar tendon in patients with OSD can be detected by SEL.

There are some strengths and limitations of the present study. To our knowledge, this is the first study that demonstrates SEL and CDUS findings in addition to US appearance in patients with acute and chronic OSD in comparison with healthy individuals. It can be challenging to differentiate tendon pathologies that has similar findings in B-mode US evaluation. However, the addition of CDUS and SEL findings to B-mode US may improve both the diagnostic accuracy and the capability of evaluation of the disease course. On the other hand, physicians may use US which is a widely applicable technique with no radiation exposure that is important for the pediatric population for the diagnosis and follow-up of the patients with OSD. The small sample size and retrospective nature of the study are the main limitations. Further prospective studies with larger sample sizes may help demonstrate the role of SEL in the evaluation of chronicity and pain relief in patients with OSD as well as diagnosis.

We demonstrated both B mode US, CDUS and SEL findings of the OSD in comparison with healthy individuals. In B-mode US evaluation, it can be challenging to differentiate different pathologies that has identical findings as discussed in the present study. However, having the knowledge of CDUS and SEL findings of OSD may help clinician to diagnose OSD more confidently. By the way, we think that, SEL will also help to demonstrate the progress of the disease in addition to B mode US and CDUS findings.

Conclusion

Distal patellar tendon in patients with OSD was thicker and softer in comparison with healthy volunteers. The intratendinous and/or peritendinous vascularity on CDUS was increased in patients with acute OSD. We suggest that these findings could be associated with tendon degeneration in OSD patients and can be useful in the evaluation of the disease.

Acknowledgments

The authors would like to express their sincere gratitude to the volunteers.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

MB: project development, data collection, data analysis, drafting the article, revising the text; SSI: data collection, data analysis, drafting the article; ISI: data collection, data analysis, drafting the article.

Ethics Approval

The study was approved by Ethical Committee of Ankara Yildirim Beyazit University (No:E1/867/2020 date: 30.09.2020). Informed consent was obtained from all the volunteers and carried out in accordance with the Helsinki declaration of principles.

Funding

The authors declare no financial support.

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Conflict of interest statement: No conflicts declared.

 How to cite this article: Balaban M, Sigit İkiz S, İdilman İS. Sonoelastography findings of the patellar tendon in Osgood-Schlatter disease. Anatomy 2022;16(1):13–18.