Diagnostic Consistency between Sonoelastography and Conventional Sonography of Long Head of the Biceps

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Background: Sonoelastography (SE) is a new technique that can assess differences in tissue stiffness, the purpose of this study was to evaluate the ability of SE to assess the long head of biceps tendon alteration.

Methods: Forty shoulders of 36 consecutively registered patients with clinical symptoms and conventional ultrasonography findings of biceps tendinitis or tendinosis, and 40 asymptomatic shoulders of 20 healthy volunteers were assessed with SE. Transverse and longitudinal images of long head of biceps tendon were obtained using SE. SE images were performed by one orthopedic surgeon and evaluated by two orthopedic surgeons using an experimentally proven color grading system.

Results: The transverse images of SE showed a sensitivity of 87.5%, a specificity of 95.0% and a accuracy of 91.3%, the longitudinal images of SE showed a sensitivity of 92.5%, a specificity of 90.0% and a accuracy of 91.3%. Inter-observer reliability of SE was in ‘almost perfect agreement’ with a weighted kappa coefficient of 0.83.

Conclusions: SE is valuable in the detection of the intratendinous and peritendinous alterations of biceps tendon, and has excellent accuracy and excellent correlation with conventional ultrasound findings.

Key Words: Biceps brachii; Tendinopathy; Elasticity imaging techniques

Introduction

Biceps tendinitis is inflammation of the tendon around the long head of the biceps muscle. Biceps tendinosis is caused by degeneration of tendon from overhead motion or from the normal aging process. Biceps tendinitis and tendinosis are commonly accompanied by rotator cuff tears or superior labrum anterior to posterior (SLAP) lesions. Patients with biceps tendinitis or tendinosis usually complain of a deep, throbbing ache in the anterior shoulder. The most common isolated clinical finding in biceps tendinitis is bicipital groove point tenderness with the arm in 10 degrees of internal rotation. Ultrasonography (US) is preferred for visualizing the overall tendon because it’s the best method by which to visualize the extra-articular portion of the biceps tendon.

The principle of Sonoelastography (SE) is that tissue compression produces strain within the tissue, which is less pronounced in harder tissue than in softer tissue. Using conventional ultrasound, it is sometimes difficult or even impossible to distinguish pathologic tissue because it often presents the same echogenicity as the surrounding healthy tissue. However, it is well known that inflammation and tumors lead to changes in tissue elasticity. Although SE is not yet used in routine clinical practice, it has been shown to be useful in the differential diagnosis of breast, thyroid, and prostate cancers, and recently was applied to lymph node characterization. However, estimation of tissue elasticity might also be a useful tool for the characterization of intratendinous focal lesions in patients presenting biceps tendinitis or tendinosis.

We hypothesized that SE findings might show higher accuracy than conventional US findings. Using clinical diagnosis with US as the standard of reference, the purpose of this study...
was to evaluate the ability of SE to assess the long head of biceps tendon (LHBT) alteration, and to compare it to SE findings of normal biceps.

**Methods**

**Subjects**

A prospective analysis between September 2013 and February 2014 was performed in 80 shoulders (patients: 40, healthy volunteers: 40) of 56 consecutive patients (patients: 36, healthy volunteers: 20), aged 20 years or older, performed by US and SE of shoulder, with chronic shoulder pain (>3 months). The institutional review board approved the study.

SE was performed on 40 shoulders of 36 consecutively enrolled patients (4 patients underwent imaging of both shoulders) with clinical symptoms and US findings of biceps tendinitis or tendinosis (26 men, 14 women; mean age, 57.6 years; range, 34−73 years). In addition, 40 shoulders of 20 healthy volunteers (23 men, 17 women; mean age, 41.7 years; range, 27−59 years) were assessed.

The healthy volunteers underwent a clinical examination to exclude biceps tendinitis or tendinosis. Further exclusion criteria for participation of healthy volunteers were a history of trauma of shoulder, tendon rupture or systemic inflammatory disorder, such as rheumatoid arthritis and hypercholesterolemia. In all cases, diagnosis of biceps tendinitis or tendinosis was carried out through clinical examination by an orthopedic surgeon of experience and included assessment of bicipital groove point and provocation tests (i.e., Yergason, Biceps loading, and speed tests). The usual complaint was a deep throbbing ache in the anterior shoulder. The pain is usually localized to the bicipital groove, but may radiate toward the insertion of the deltoid muscle. The mean duration of symptoms was 6.2 months (range, 3−24 months).

In patients group, the cases with other concomitant shoulder disorders were not excluded. There were 12 full thickness rotator cuff tear, 21 partial thickness rotator cuff tear in 36 patients. Labral lesions were not evaluated.

In this study, biceps tendinitis and tendinosis are diagnosed when patients have positive signs of physical exams with abnormal US finding of biceps tendon and around structure (≥grade 1). In all patients, the ambiguous cases (only one abnormal finding between the physical exams and US findings), subluxation or dislocation of LHBT, complete rupture of LHBT, or previous surgery on the affected shoulder, were ruled out by clinical examination and radiologic findings. We defined that positive sign of biceps tendinitis and tendinosis in SE finding as more than one focal lesion (≥grade 1).

**Sonoelastography and Ultrasonography Imaging**

The US examination was standardized according to a previously published technique.10 The patient sat on a chair, with the examiner stood behind the patient. The US assessment is performed with the arm in neutral position. The arm should be positioned in supination on the patient’s thigh. The transducer is placed perpendicular to the LHBT, at the anterior aspect of the shoulder and is used to identify the intertubercular sulcus. Both transverse and longitudinal views should be obtained at most abnormal portion of LHBT the bicipital groove. SE images were obtained on the same plane without moving probe.

SE and US were performed using a Siemens Acuson S2000 (Siemens Medical Solutions USA Inc., Malvern, PA, USA), with linear array transducer with a frequency of 4 to 9 MHz. The calculation of tissue elasticity distribution was in real time (up to 30 frames/s) and the examination results were represented in color over the conventional B-mode imag.6 SE images are obtained when the transducer was perpendicular to the LHBT with mild compression, the degree of compression being based on a quality factor that was shown on the monitor of the ultrasonic apparatus. We set the standard of quality factor when it was 65. SE images are composed by 256 degrees color map and configured so that soft tissue shows red and hard tissue shows blue.

US images were graded: grade 0: normal finding of biceps tendon and tendon sheath; grade 1: mild filling of the tendon sheath, appearing as an anechoic ring around the tendon (<2 mm). There was no change in the structure of the tendon; grade 2: an anechoic ring around the tendon was clearly visible and measured 2 to 3 mm. The structure of the tendon was mildly inhomogeneous (<50%); grade 3: the tendon sheath appeared as an anechoic structure surrounding the tendon and was severely widened and extended further distally than medially. The tendon was at least moderately to severely inhomogeneous (≥50%), thickened, or reduced to a stump. The wall of the tendon sheath was visible as a hyperechoic border.12

SE images were evaluated for the presence of focal lesions, including areas of degeneration and intratendinous tear, which were defined as red to yellow (soft) areas at SE. Focal lesions were counted to evaluate the dimensions of focal lesions according to the following grading system: 0, no focal lesion or blue to green (hard) tendon; 1, one focal lesion; 2, two focal lesions; 3, more than two focal lesions. At least three scans of each view were performed, and mean values of grades of three scans were used as representative values.

US and SE were performed by another orthopedic surgeon (Jae-Sung Yoo) experience in US imaging who was blinded to the clinical findings. The images were interpreted after the initial scanning by the same orthopedic surgeon. To evaluate inter-observer variability, a third orthopedic surgeon (Jee-Won Ryu) with experience assessed the same US and SE images. Both orthopedic surgeons were blinded to the clinical results.
Statistical Analysis

Power analysis indicated that a sample size of forty cases per group would provide 95% statistical power to detect this effect size between the groups (alpha = 0.05, beta = 0.20 previous accuracy of US = 73,13 accuracy of SE = 92.712). Weighted kappa (κ) coefficient was used to estimate the inter-observer reliability in evaluation of SE images, inter-observer reliability was classified according to the κ coefficients. ‘Slight agreement’, 0.00−0.20; ‘fair agreement’, 0.21−0.40; ‘moderate agreement’, 0.41−0.60; ‘substantial agreement’, 0.61−0.80; ‘almost perfect agreement’, 0.81−1.00. All statistical analyses were performed with IBM SPSS Statistics version 19.0 (IBM Co., Armonk, NY, USA), and the level of significance was set at $p < 0.05$.

Results

Results in Biceps Tendinitis and Tendinosis Group

In transverse view using US, grades 1, 2, and 3 were determined for 17.5%, 32.5%, and 50.0% of patients, respectively. In transverse view using SE, grades 0, 1, 2, and 3 were determined...
in 12.5%, 37.5%, 15.0%, and 35.0% of patients (Fig. 1). In longitudinal view using US, grades 1, 2, and 3 were determined in 12.5%, 27.5%, and 60%, respectively. In longitudinal view using SE, grades 0, 1, 2, and 3 were determined in 7.5%, 0.0%, 15.0%, and 77.5% of patients (Fig. 2, Table 1).

Results in Healthy Volunteers
In transverse view using US, grades 0, 1, 2, and 3 were found in 92.5%, 5.0%, 2.5%, and 0.0% of patients, respectively. In transverse view using SE, grades 0, 1, 2, and 3 were found in 75.0%, 15.0%, 7.5%, and 2.5% (Fig. 3). In longitudinal view using US, grades 0, 1, 2, and 3 were found in 66.7%, 21.1%, 8.8%, and 3.5% of patients, whereas in longitudinal view using SE, grades 0, 1, 2, and 3 were found in 79.8%, 12.3%, 3.5%, and 4.4% of patients (Fig. 4, Table 1).

Specificity, Sensitivity, Accuracy and Correlation
When comparing SE to standard clinical and US findings, the sensitivity of transverse view was 87.5%, and the specificity was 95.0%. The accuracy of SE was 91.3% when only distinct elasticity alterations of grade 1, 2, and 3 were considered, as pathological longitudinal view of SE showed a sensitivity of 92.5%, a mean specificity of 90.0%, and a mean accuracy of 91.3%, when considering grade 1, 2, and 3 as pathological.

Inter-observer reliability of US was in ‘substantial agreement’ with a weighted kappa coefficient of 0.72 and inter-observer reliability of SE was in ‘almost perfect agreement’ with a weighted kappa coefficient of 0.83.

Discussion
Inflammation of the biceps tendon within the intertubercular groove is called biceps tendinitis, only 5% of biceps tendinitis were primary biceps tendinitis without other shoulder disorder.\(^1\) The 95% of patients without primary biceps tendinitis usually have an accompanying rotator cuff tear or tear of the SLAP lesion.\(^1\) Pathology of the biceps tendon is most often found in patients 18 to 35 years of age who are involved in sports.\(^2,3\) Biceps tendinitis may also refer to tendinosis, which is a syndrome of overuse and degeneration. Older patients (i.e., athletes older
than 35 years, or non-athletes older than 65 years) may have acute biceps tendinitis caused by sudden overuse, or biceps tendinosis caused by use over time.\textsuperscript{14}

Several imaging modalities can be used to evaluate tendinosis. For instance, US and magnetic resonance imaging (MRI) are considered superior to conventional radiography or computed tomography scanners.\textsuperscript{15,16} MRI is the most widely-used method of imaging the rotator cuff. However, the agreement between MRI and arthroscopic findings had been shown to be poor, at only 60%, with a concordance of only 37% in diagnosing pathology in the biceps tendon.\textsuperscript{17} US has shown an overall sensitivity of 49% and a specificity of 97%.\textsuperscript{13} Although, US was poor at diagnosing intra-articular partial tears of the tendon in difficult to scan patients who are obese, and requires an experienced operator. Nevertheless, it will become imaging study of choice because of it has many advantages; relatively inexpensive, may be used for patients with metallic implants; possible to examine dynamic technique; no ionizing radiation; offers better spatial resolution than MRI, and may be used for local anesthetic or corticosteroid injections into the biceps tendon sheath.\textsuperscript{18-21}

However, it can be difficult or even impossible to differentiate tissue affected by degenerative disease from healthy tissue, because damaged tissue often has the same echogenicity as the surrounding healthy tissue upon conventional ultrasound.\textsuperscript{6} However, it is well known that inflammation and degeneration cause changes in tissue elasticity.\textsuperscript{6} Thus, the estimation of tissue softening may be a useful tool for characterization of an intratendinous focal lesion or peritendinous involvement in patients with biceps tendinitis or tendinosis.

Tendinosis involves collagen break down that softens and weakens the tendon, eventually leading to tendon tear or rupture.\textsuperscript{22} These histopathologic alterations of tendinosis have been found to increase the compressibility of tissue at ultrasound, and may cause softening of tissue at SE.\textsuperscript{23} De Zordo et al.\textsuperscript{24,25} reported that SE is valuable in the detection of the intratendinous and peritendinous alteration of lateral epicondylitis or Achilles tendinopathy. In this study, both transverse images ($r = 0.791$, $p \leq 0.001$) and longitudinal images ($r = 0.79$, $p \leq 0.001$) of SE

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![Figure 5](image_url)

**Fig. 5.** Ultrasonography and sonoelastography images of 49-year-old female with biceps tendinosis. (A) Transverse image of ultrasonograph of grade 2 biceps tendinosis shows mild (<50%) inhomogeneous biceps tendon. (B) Transverse image of sonoelastography shows no focal lesion. (C) Longitudinal image of ultrasonograph of grade 3 biceps tendinosis shows moderately to severely (>50%) inhomogeneous biceps tendon. (D) Longitudinal image of sonoelastography of grade 3 biceps tendinosis shows more than two focal lesions.
were found to have positive correlation with US images.

Our study has the following limitations: first, there is lack of consensus regarding the definition of biceps tendinitis and tendinosis of SE techniques; second, we correlated SE finding with US findings only, but further comparison with arthroscopic findings and histopathology results would be very interesting; third, the patient group included not only primary biceps tendinitis or tendinosis but also secondary biceps tendinitis or tendinosis; fourth, although there was no statistically significant difference between two groups, our control group was not age-matched with respect to the patients.

Underestimation of the grade of SE with transverse view has to be considered, sensitivity of transverse view (87.5%) was lower than sensitivity of longitudinal view (92.5%) in this study. Because, whole length of biceps tendon can be assessed with longitudinal view whereas only one cross section image of biceps can be evaluated in transverse view (Fig. 5). Moreover, elasticity of tendon is harder than elasticity of fluid around tendon, therefore underestimation the grade of SE when large amount of fluid was detected around biceps tendon also should be noted (Fig. 6). Furthermore, only number of focal lesions are considered without estimating of size of lesions to evaluated grading of SE in this study. Therefore, further study with quantitative assessment should be helpful for more accurate evaluation of biceps tendon.

SE is a technique which is relatively highly operator dependent, in terms of the application of pressure to the probe and the differentiation of artifacts from diagnostic image information. Although operator dependency is a known challenge in US, we tried to obtain appropriate images by maintaining a level of pressure on the probe with monitoring of quality factor. Although interobserver reliability is high (κ = 0.83) in this study, SE images were obtained by only one operator. Due to the high operator dependency of SE, further assessment of images of LHBT obtained by more operators could be useful for a more accurate evaluation of interobserver reliability.

**Conclusion**

SE is valuable in the detection of the intratendinous and peri-tendinous alterations of LHBT and has excellent accuracy and excellent correlation with conventional ultrasound findings.

**References**