Sonoelastography findings of biceps tendinitis and tendinosis

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Received: 28 November 2013 / Accepted: 6 February 2014 / Published online: 13 March 2014
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Abstract

Objective The purpose of this study was to evaluate sonoelastography (SE) in the assessment of the long head of biceps tendon (LHBT) in patients with symptoms of biceps tendinitis or tendinosis and in patients without biceps lesion. The findings were compared with those obtained at clinical examination, using ultrasonography (US).

Materials and methods 36 shoulders of 34 consecutively registered patients with clinical symptoms and US findings of biceps tendinitis or tendinosis, and 114 shoulders of 98 patients without biceps lesions were assessed with SE. Transverse and longitudinal images of LHBT were obtained using SE. SE images were evaluated by reviewers using an experimentally proven color grading system.

Results The transverse images of SE showed a mean sensitivity of 69.4 %, a mean specificity of 95.6 % and a mean accuracy of 89.3 %. Good correlation of conventional ultrasound findings was found ($p < 0.001$, $r = 0.763$). The longitudinal images of SE showed a mean sensitivity of 94.4 %, a mean specificity of 92.1 % and a mean accuracy of 92.7 %. Good correlation of conventional ultrasound findings was found ($p < 0.001$, $r = 0.585$). Inter-observer reliability of SE was in “almost perfect agreement” with a weighted kappa coefficient of 0.84.

Conclusions SE has potential to be clinically useful in the detection of the intratendinous and peritendinous alterations of LHBT and has excellent accuracy and excellent correlation with conventional ultrasound findings.

Keywords Biceps · Tendinitis · Tendinosis · Sonoelastography

Riassunto

Obiettivo Lo scopo di questo studio è stato quello di valutare l'efficacia della elastosonografia (SE) nello studio del tendine del capo lungo del bicipite (LHBT) in pazienti con sintomi quali tendiniti o tendinosi del muscolo bicipite ed in pazienti asintomatici. I risultati ottenuti sono stati messi a confronto con i dati derivanti dall'esame clinico del paziente e dall'ultrasonografia (US).

Materiali e metodi Mediante SE sono state studiate 36 spalle di 34 pazienti sintomatici con evidenza all'ecografia di segni di tendinite o tendinosi del muscolo bicipite e 114 spalle di 98 pazienti che non presentavano lesioni del muscolo bicipite. Alla SE, sono state ottenute immagini con scansioni trasversali ed assiali del tendine del capo lungo del muscolo bicipite. Le immagini ottenute mediante SE sono state valutate da alcuni revisori che utilizzano un sistema comprovato di gradazione del colore.

Risultati Le immagini SE ottenute secondo una scansione trasversale hanno mostrato sensibilità media del 69.4 %, una specificità media del 95.6 % ed una accuratezza media del 89.3 %. E' stata riscontrata una buona correlazione con i dati ottenuti mediante US ($p < 0.001$, $r = 0.763$). Le immagini SE ottenute secondo una scansione longitudinale hanno mostrato una sensibilità media del 94.4 %, una specificità media del 92.1 % ed una accuratezza media del 92.7 %. E' stata ottenuta una buona correlazione con i dati ultrasonografici ($p < 0.001$, $r = 0.585$). La variabilità interosservatore della SE è stata stimata avere un coefficiente k pesato in “accordo quasi perfetto” di 0.84.

Conclusioni E' stato dimostrato come la SE mostri utilità clinica per lo studio delle lesioni intratendinee e

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peritendinee del LHBT con una grande correlazione ed accuratezza con i reperti evidenziati all' US convenzionale.

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 [1]. Biceps tendinitis and tendinosis are commonly accompanied by rotator cuff tears or superior labrum anterior to posterior (SLAP) lesions [2, 3]. 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° of internal rotation [1]. Ultrasonography (US) is preferred for visualizing the overall tendon, because it is the best method to visualize the extra-articular portion of the biceps tendon [4].

Sonoelastography (SE) is a new technique that can assess differences in tissue stiffness [5]. Ophir et al. [6] first described the principle of strain imaging (“elastography”) in 1991; in 1999, Pesavento et al. [7] developed a fast elastography-based cross-sectional technique to allow its use in clinical practice. The principle of SE is that tissue compression produces strain within the tissue, which is less pronounced in harder tissue than in softer tissue [8]. 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 [9]. However, it is well known that inflammation and tumors lead to changes in tissue elasticity [9]. Although sonoelastography is not yet used in routine clinical practice, it has been shown to be useful in the differential diagnosis of breast [8, 10], thyroid [11], and prostate [12] cancers, and recently was applied to lymph node characterization [13]. 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 be correlated with 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.

Materials and methods

Subjects

The institutional review board approved the study; a retrospective analysis between March 2012 and January 2013

was performed in 150 shoulders (biceps tendinitis or tendinosis: 36, no biceps lesion: 114) of 132 consecutive patients (biceps tendinitis or tendinosis: 34, no biceps lesion: 98), aged 20 years or older, performed by US and SE of shoulder, with chronic shoulder pain (>6 months).

Sonoelastography was performed on 36 shoulders of 34 consecutively enrolled patients (2 patients underwent imaging of both shoulders) with clinical symptoms and US findings of biceps tendinitis or tendinosis (15 men, 19 women; mean age, 46.9 years; range, 31–73 years). In addition, 114 shoulders of 98 patients without biceps lesions (57 men, 41 women; mean age, 43.9 years; range, 20–76 years) were assessed.

In all patients, diagnosis of biceps tendinitis or tendinosis was carried out through clinical examination by an orthopedic surgeon with 20 years 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 time of symptoms was 13.2 months (range 6–48 months).

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 ($\geq$ grade 1). Non-biceps lesions were defined as negative signs of physical exams with normal US findings of biceps tendon and around structure (grade 0). 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 positive sign of biceps tendinitis and tendinosis in SE finding as more than one focal lesion ($\geq$ grade 2).

SE and US imaging

The US examination was standardized according to a previously published technique [14]. 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 the bicipital groove.

Sonoelastography 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 4–9 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 image. [9] 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° color map and configured so that soft tissue shows red and hard tissue shows blue.

Ultrasonography 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 2–3 mm. The structure of the tendon was mildly in homogeneous (<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.

Sonoelastography 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.

Ultrasonography and SE were performed by another orthopedic surgeon with 8 years of 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 with 4 years of experience assessed the same US and SE images. Both orthopedic surgeons were blinded to the clinical results and US images.

Statistical analysis

Spearman's correlation coefficient was used to estimate the correlation of SE images with conventional US images. 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 SPSS version 19.0 (SPSS Inc., Chicago, IL, 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 16.7, 33.3, and 50.0 % of patients, respectively. In transverse view using SE, grades 0, 1, 2 and 3 were determined in 11.1, 22.2, 27.8 and 38.9 % of patients, respectively (Fig. 1).

In longitudinal view using US, grades 1, 2 and 3 were determined in 11.1, 30.6, and 58.3 %, respectively. In longitudinal view using SE, grades 0, 1, 2 and 3 were determined in 2.8, 5.6, 16.7 and 75.0 % of patients, respectively (Fig. 2; Table 1).

Results in non-biceps lesion group

In transverse view using US, grades 0, 1, 2 and 3 were found in 83.3, 13.2, 2.6, and 0.9 % of patients, respectively. In transverse view using SE, grades 0, 1, 2 and 3 were found in 87.7, 7.9, 0.9 and 3.5 % (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, respectively (Fig. 4; Table 1).

Fig. 1 **a** Transverse image of ultrasonography of grade 3 biceps tendinosis shows large amount of fluid filling the tendon sheath, and the tendon was moderate to severely inhomogeneous. **b** Transverse image of sonoelastography of grade 3 biceps tendinosis shows more than two focal lesions. Arrows indicate biceps tendon

Fig. 2 **a** Longitudinal image of ultrasonography of grade 3 biceps tendinosis shows moderately to severely inhomogeneous biceps tendon. **b** Transverse image of sonoelastography of grade 3 biceps tendinosis shows more than two focal lesions. Arrowheads indicate the focal lesions of biceps tendon

Table 1 Correlation between grade of ultrasonography and sonoelastography findings

	View	Grade	Sonoelastography				<i>P</i> value	Correlation coefficient
			0	1	2	3		
Ultrasonography	Transverse view	0	89	5	1		<0.001	0.763
		1	12	7	0	2		
		2	1	5	2	7		
		3	2	0	8	9		
	Longitudinal view	0	61	11	3	1	<0.001	0.585
		1	21	3	0	4		
		2	7	2	3	9		
		3	3	0	4	18		

Fig. 3 **a** Transverse image of ultrasonography of grade 0 shows homogenous biceps tendon. **b** Transverse image of sonoelastography of grade 0 biceps tendinosis shows no focal lesions. Arrows indicate biceps tendon

Specificity, sensitivity, accuracy and correlation

When comparing SE to standard clinical and US findings, the mean sensitivity of transverse view was 69.4 %, and the mean specificity was 95.6 %. The mean accuracy of SE was 89.3 % when only distinct elasticity alterations of grade 2 and grade 3 were considered, as pathological

longitudinal view of SE showed a mean sensitivity of 94.4 %, a mean specificity of 92.1 % and a mean accuracy of 92.7 %, when considering grade 2 and 3 as pathological (Table 2).

By comparing SE findings with US findings, both transverse images ($r = 0.763$, $p = <0.001$) and longitudinal images ($r = 0.585$, $p = <0.001$) of SE have positive

Fig. 4 **a** Longitudinal image of ultrasonography of grade 0 shows homogenous of biceps tendon. **b** Longitudinal image of sonoelastography of grade 0 biceps tendinosis shows no focal lesions

Table 2 Sensitivity, specificity, and accuracy of sonoelastography

Sonoelastographic finding	Transverse images of sonoelastography		Longitudinal images of sonoelastography	
	Biceps tendinitis or tendinosis <i>N</i> = 36	No Biceps lesion <i>N</i> = 114	Biceps tendinitis or tendinosis <i>N</i> = 36	No Biceps lesion <i>N</i> = 114
Positive finding of biceps tendinitis or tendinosis (grade 2, 3)	25	5	34	9
Negative finding of biceps tendinitis or tendinosis (grade 0, 1)	11	109	2	105

correlation with US images (Table 1). 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 0.84.

Discussion

Inflammation of the biceps tendon within the intertubercular groove is called primary biceps tendinitis, which occurs in 5 % of patients with biceps tendinitis [1]. The 95 % of patients without primary biceps tendinitis usually have an accompanying rotator cuff tear or tear of the superior labrum anterior to posterior (SLAP) lesion [1]. Pathology of the biceps tendon is most often found in patients 18–35 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 [15].

Several imaging modalities can be used to evaluate tendinosis. For instance, US and MRI are considered superior to conventional radiography or computed

tomography scanners [16, 17]. 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 [18]. Ultrasonography has shown an overall sensitivity of 49 % and a specificity of 97 % [19]. Although ultrasonography is 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 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 [20–23].

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 [9]. However, it is well known that inflammation and degeneration cause changes in tissue elasticity [9]. 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 [24]. These histopathologic alterations of tendinosis have been found to increase the compressibility of tissue at ultrasound, and may cause softening of tissue at SE [25]. De Zordo et al. [26, 27] 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 ($r = 0.763$, $p = <0.001$) and longitudinal images ($r = 0.585$, $p = <0.001$) of SE were found to have positive correlation with US images.

Our study has the following limitations: first, our study population was a relatively small and retrospective study; second, there is lack of consensus regarding the definition of biceps tendinitis and tendinosis of SE techniques; third, we correlated SE finding with US findings only, but further comparison with arthroscopic findings and histopathology results would be very interesting; fourth, the control group included only patients (i.e., impingement syndrome, rotator cuff tear, labral lesions, instability, calcific tendinitis, or adhesive capsulitis) without biceps lesion, and not normal healthy volunteers. Furthermore, SE is a technique which is relatively highly operator-dependant, 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. Nevertheless, it is considered that this study is meaningful because the study attempted to analyze the correlation of SE findings with US finding in biceps tendinitis and tendinosis for the first time.

Conclusion

Sonoelastography has potential to be clinically useful in the detection of the intratendinous and peritendinous alterations of LHBT and has excellent accuracy and excellent correlation with conventional ultrasound findings. However, further studies (comparison with arthroscopic findings and histopathology) have to be carried out to confirm accuracy of SE in biceps tendinitis or tendinopathy.

Conflict of interest Joong-Bae Seo, M.D., Jae-Sung Yoo, M.D., Jee-Won Ryu, M.D. declare that they have no conflict of interests.

Informed consent All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000 (5). All patients provided written informed consent to enrollment in the study and to the inclusion in this article of information that could potentially lead to their identification.

Human and animal studies The study was conducted in accordance with all institutional and national guidelines for the care and use of laboratory animals.

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