Original article

Diagnostic confidence of sonoelastography as adjunct to greyscale ultrasonography in lateral elbow tendinopathy

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Keywords: *sonoelastography; ultrasonography; tennis elbow; tendons*

Background Conventional ultrasonography or magnetic resonance (MR) imaging is commonly performed to obtain information about the severity of the disease, location of the injury, and differential diagnosis. The aim of this research was to investigate the diagnostic confidence of sonoelastography as an adjunct to greyscale ultrasonography in lateral elbow tendinopathy.

Methods A single experienced physiatrist performed greyscale ultrasonography and sonoelastography in 28 patients (9 men, 19 women; mean age, 48.5 years; age range, 36–67 years) with unilateral symptoms of lateral elbow tendinopathy; the asymptomatic elbows were used as controls. Greyscale images were described as normal, tendinosis, partial-thickness tear, and full-thickness tear. Sonoelastographic images of the common extensor tendon were analyzed qualitatively (scoring of the elastic spectrum) and quantitatively (based on a color histogram).

Results Both the imaging methods had high sensitivity, specificity, and accuracy for diagnosing lateral elbow tendinopathy. Considering the clinical diagnosis of lateral elbow tendinopathy, sonoelastography showed significantly higher diagnostic accuracy (96.4%) than ultrasonography (89.5%, P <0.01). Quantitative analysis showed objective interpretation of the sonoelastographic images that revealed greater intensity of green and blue pixels in symptomatic elbows (P <0.01).

Conclusion Sonoelastography increases diagnostic confidence in tennis elbow pathology over greyscale ultrasonography alone and may be an additional powerful diagnostic tool in cases of lateral elbow tendinopathy with inconclusive greyscale ultrasonographic findings.

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Lateral elbow tendinopathy, commonly known as tennis elbow or lateral epicondylosis, is caused by overuse of the common extensor tendon.[1] Clinically, it is characterized by elbow pain at the lateral epicondyle that is aggravated by repetitive use of the extensor muscles of the wrist during activities of daily living, sports, and job-related functions. On physical examination, affected individuals exhibit localized tenderness around the lateral epicondyle and pain exacerbated by isometric-resisted wrist extension or finger extension.[1]

The diagnosis of lateral elbow tendinopathy is usually based on the clinical findings; most patients respond to conservative treatment including rest, bracing, physical therapy, and medications or steroid injections.[2] Therefore, imaging studies are often not required. However, conventional ultrasonography or magnetic resonance (MR) imaging is commonly performed to obtain information about the severity of the disease, location of the injury, and differential diagnosis.[3,4] MR imaging is reportedly more sensitive than ultrasonography in detecting and clarifying the characteristics of the disease.[5,6] However, recent ultrasonographic developments have enabled the use of ultrasonography as an alternative to MR imaging in the diagnosis of tendon pathology. Ultrasonography is a noninvasive, inexpensive technique and allows dynamic assessment.[1] Several studies have demonstrated variable sensitivity and specificity of this modality for diagnosing lateral elbow tendinopathy.[3,7,8] Tendon compressibility and elasticity have been regarded as helpful diagnostic criteria in the ultrasonographic assessment of this disease.[9,10]

Sonoelastography is a recently developed technique based on ultrasonography that evaluates tissue elasticity in real time. Its principle is that tissue compression produces some strain (displacement), which is lower in hard tissue and higher in soft tissue.[11] Because tendon pathology is closely related to tissue elasticity, sonoelastography could provide additional diagnostic information on greyscale ultrasonography which focused on structural consideration. The aim of this study is to evaluate diagnostic confidence of sonoelastography in tennis elbow pathology as an adjunct to greyscale ultrasonography.

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METHODS

Subjects

Twenty-eight consecutive patients (9 men, 19 women; mean age, 48.5 years; age range, 36–67 years) who showed symptoms of lateral elbow tendinopathy and visited the outpatient clinic were enrolled in the study. All the patients had unilateral symptoms, and their asymptomatic elbows were used as controls. The mean symptom duration was 22.6 months (range, 1–150 months).

Clinical diagnosis of lateral elbow tendinopathy was based on the reported symptoms and signs during a physical examination performed by a physiatrist. Symptoms in inclusion criteria were as follows: pain on the outer part of the elbow, pain from gripping and movements of the wrist, especially wrist extension and lifting movements, pain from activities that use the muscles that extend the wrist. The examination included inspection and evaluation of local tenderness over the lateral epicondyle on palpation. The exclusion criteria were entrapment neuropathies of the upper limb, fracture or bony metastases of the elbow, systemic inflammatory disorders such as rheumatoid arthritis, and history of surgery.

Some medical histories and physical examinations were recorded for analysis, such as symptom duration, subjective pain rating (visual analog scale), and histories of steroid injection. What kind of resistive motion (wrist extension and/or middle finger extension) triggered pain was also evaluated; that is clinically significant because pain in wrist extension is related to the pathology in the deep layer of common extensor tendon, whereas pain in middle finger extension is related to the superficial layer.

The study was approved by the institutional review board, and all the subjects provided written informed consent for participation.

Ultrasonography

A physiatrist with 8 years of experience in musculoskeletal ultrasonography and 2 years of experience in sonoelastography performed greyscale ultrasonography and sonoelastography using a commercially available ultrasound system with a 5–13 MHz multifrequency linear transducer (ACUSON Antares ultrasound system, premium edition; Siemens Healthcare, Erlangen, Germany). Power Doppler examination was also performed. The examiner was blinded to the symptoms and clinical histories of the subjects. The reviews of both normal and abnormal were done in a randomized way and separate exams unlinked to the same patient and in a blinded fashion. During the ultrasonographic examination, each subject was seated comfortably with the elbow in flexion, the wrist in pronation, and the arm in internal rotation while resting on a table. Greyscale and power Doppler images of the common extensor tendon were acquired in the longitudinal and transverse planes from the musculotendinous junction to the insertion on the lateral epicondyle. To avoid anisotropy, the transducer was kept parallel to the tendons in the longitudinal plane and perpendicular in the transverse plane. Both the elbows were examined in the same manner. The common extensor tendon was assessed for ultrasonographic abnormalities such as abnormal echogenicity, thickening, nonvisualization, increased vascularity, intratendinous calcification, and cortical irregularities. The severity of the tendon pathology was described as tendinosis (focal hypoechoic area without fiber discontinuity or intratendinous calcification), partial-thickness tear (focal anechoic area with fiber discontinuity involving only the partial width of the tendon), or full-thickness tear (distinct complete interval extending through the full width or nonvisualization of the tendon).[7,12] The location of the abnormalities was classified into three sections, the anterior, middle, and posterior fibers,[7] and two layers, the superficial and deep layers.

Sonoelastography

For sonoelastography, the subject and transducer positioning was identical to that in greyscale ultrasonography. The greyscale image was displayed on the left side of the screen and the color-coded sonoelastographic image was depicted on the right.

The color scale of the sonoelastographic images varied from red (hardest) to purple (softest), with yellow and green as the intermediate grades. The elastic pattern of the common extensor tendon was graded by the physiatrist according to previously reported sonoelastographic scores[13] (Table 1): 1 (purple to green; soft), 2 (green to yellow), 3 (yellow to red), and 4 (red; hard). Usually, a normal tendon is depicted in red, tendinosis is defined as a green-to-yellow change, and a tendon tear is indicated as a purple-to-green change (soft).

For quantitative analysis, a standardized polygon of the common extensor tendon was selected as the region of interest (ROI) with its border from the proximal insertion point of the tendon to 2 cm distal to the insertion. Bony cortex was not included in the ROI. Image J software (version 1.42q; National Institutes of Health, Bethesda, MD, USA) was used for the color histogram of the common extensor tendon. In the program, each pixel was separated into red, green, and blue components (color intensity range, 0–255). The color histogram represents the number of pixels that have colors in each of fixed lists of color ranges and calculates the intensity of each color component of the pixels within the ROI. Higher value was defined as greater color intensity. The program provided the mean pixel

Table 1. Sonoelastographic scoring system for the common extensor tendon

Score	Interpretation	Sonoelastographic appearance
1	Soft	Purple or green in the region of interest
2	Mostly soft	Green or yellow and a few small areas of red in the region of interest
3	Mostly hard	Red and yellow areas present in nearly the same distribution in the region of interest
4	Hard	Predominantly red and a few small areas of green in the region of interest

A few small areas mean less than 10% in the region of interest.

values of the color components within the polygon.

Statistical analysis

Statistical analysis was performed by using SPSS version 18.0 software (IBM, Inc., Armonk, NY, USA). The null hypothesis was rejected if the *P*-value was less than 0.05.

The clinical diagnosis of lateral elbow tendinopathy was considered as the standard of reference. The diagnostic indices (sensitivity, specificity, positive predictive value, negative predictive value, and accuracy) of ultrasonography and sonoelastography were calculated. The McNemar test was used to compare the diagnostic accuracies of the imaging methods. The Mann–Whitney *U*-test was used to compare the mean values of the color histograms of the common extensor tendon between the asymptomatic and the symptomatic elbows. The Pearson χ^2 test was used to estimate the relationships between the ultrasonographic and the sonoelastographic images for the severity of the tendon pathology, between pain on resistive middle finger extension and location of the abnormal findings, between the sonoelastographic score and the other findings, and between the presence of steroid injection and the others.

RESULTS

Diagnostic values

On ultrasonography, 12 cases of tendinosis, 12 partial-thickness tears, and one full-thickness tear were observed in the symptomatic elbows, whereas two cases of tendinosis were found in the asymptomatic elbows. Normal ultrasonographic findings were found in three symptomatic elbows. Sonoelastography revealed 18 cases of tendinosis and nine partial-thickness tears in the symptomatic elbows and one case of tendinosis in the asymptomatic elbows. Using clinical tennis elbow as a gold standard, sonoelastography showed significantly higher diagnostic accuracy (96.4%) than ultrasonography (89.5%, $P<0.01$). The results of the imaging examinations and their diagnostic indexes are presented in Table 2. Figures 1–3 show the spectrum of ultrasonographic and sonoelastographic patterns experienced in this study. The severity of the tendon pathology estimated by ultrasonography and sonoelastography showed a significant correlation ($P<0.01$; Table 3).

Quantitative analysis of the sonoelastographic images

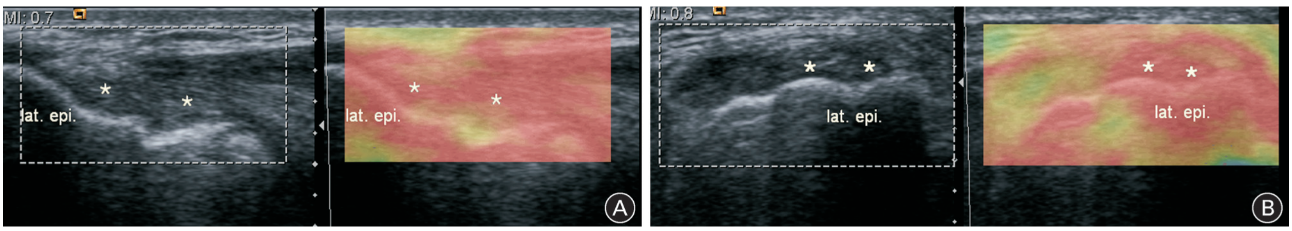

Figure 1. An asymptomatic elbow with a normal common extensor tendon in a 45-year-old patient (**A**: longitudinal view; **B**: transverse view). The greyscale ultrasonographic images (left) show the normal structure of the common extensor tendon (asterisks) and the sonoelastographic images (right) show sonoelastographic score 4 (hard) with the red elastic spectrum. lat. epi.=lateral epicondyle.

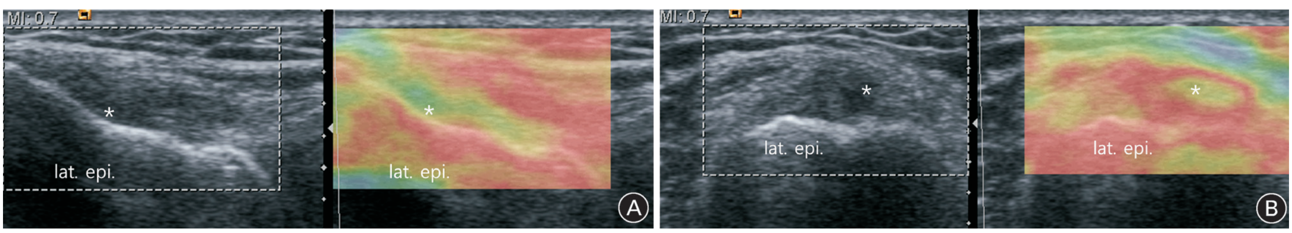

Figure 2. Greyscale ultrasonographic and sonoelastographic images showing tendinosis of the common extensor tendon in a 48-year-old housewife (**A**: longitudinal view; **B**: transverse view). The ultrasonographic images (left) depict areas of softening (asterisks; sonoelastographic score 2 (mostly soft)); note the green-to-yellow contrast to the surrounding red area in the sonoelastographic images (right). lat. epi.=lateral epicondyle.

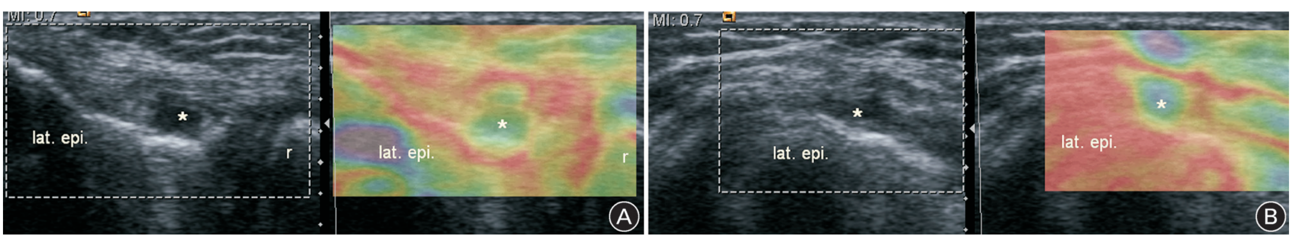

Figure 3. Greyscale ultrasonographic and sonoelastographic images of a partial-thickness tear of the common extensor tendon in a 38-year-old female violinist (**A**: longitudinal view; **B**: transverse view). The ultrasonographic images (left) depict areas of softening (asterisks; sonoelastographic score 1 (soft)); note the purple-to-green contrast to the surrounding red area in the sonoelastographic images (right). lat. epi.=lateral epicondyle; r=radial head.

Table 2. Results of greyscale US, sonoelastography, and diagnostic performance indexes for ultrasonographic/sonoelastographic lateral epicondylosis

Parameters	Greyscale ultrasonography	Sonoelastography	Absolute difference or percentage increase
False-negative findings	10.7% (3/28)	3.6% (1/28)	–2
True-positive findings	89.3% (25/28)	96.4% (27/28)	+2
False-positive findings	7.4% (2/27)	3.6% (1/28)	–1
True-negative findings	10.3% (3/29)	3.6% (1/28)	–2
Sensitivity	89.3% (25/28)	96.4% (27/28)	7.1%
Specificity	89.7% (26/29)	96.4% (27/28)	6.8%
Overall accuracy	89.5% (51/57)	96.4% (54/56)	7.0%*
Positive predicted value	92.6% (25/27)	96.4% (27/28)	3.8%
Negative predicted value	89.7% (26/29)	96.4% (27/28)	6.8%

Data are presented in percentages with numerator and denominator in parenthesis. *P <0.01 (McNemar test).

Table 3. Severity of common extensor tendon pathology classified by ultrasonography and sonoelastography in lateral epicondylosis

Ultrasonography	Sonoelastography		
	Normal (n=1)	Tendinosis (n=18)	Tendon tear (n=9)
Normal (n=3)	1	2	0
Tendinosis (n=12)	0	11	1
Tendon tear (n=13)	0	5	8

revealed the mean pixel values of the red, green, and blue components of the color histogram as 174.4±4.4, 118.8±11.8, and 106.9±4.5 for the asymptomatic elbows and 162.9±10.4, 127.6±15.6, and 119.3±10.5 for the symptomatic elbows, respectively. The asymptomatic elbows showed a significantly greater intensity of red (P <0.01); on the other hand, the intensities of green and blue were significantly greater in the symptomatic elbows (P <0.01 and P <0.05, respectively; Figure 4).

Abnormal findings

During the physical examination, 16 subjects had pain around the lateral epicondyle on resistive middle finger extension. Ultrasonography and sonoelastography showed abnormal findings in the superficial layer of the common extensor tendon in 11 of these subjects (P <0.05; Table 4, Figure 5).

A low sonoelastographic score (soft tissue) was significantly correlated with cortical irregularities around the lateral epicondyle and symptom duration (P <0.05). Further, the subjects (n=16) who had received steroid injections had lower sonoelastographic scores than the other subjects (P <0.05). However, the sonoelastographic score was not significantly associated with the subjective pain rating (visual analog scale) and power Doppler findings. The subjects who had received steroid injections frequently had a higher pain rating, longer symptom duration, and greater vascularity in the power Doppler examination (P <0.05).

DISCUSSION

Repetitive overuse and microtrauma of the extensor forearm muscle is considered a cause of lateral elbow tendinopathy and results in tendon degeneration with vascular compromise such as anoxia and angiofibroblastic

Table 4. Comparison between ultrasonographic/sonoelastographic findings and lateral epicondyle pain on middle finger extension

Ultrasonographic finding	With superficial lesion	Without superficial lesion	Total
Pain	11	5	16
No pain	2	10	12
Sonoelastographic finding			
Pain	11	5	16
No pain	4	8	12

The ultrasonographic/sonoelastographic findings of superficial lesion in common extensor tendon showed significant correlation with lateral epicondyle pain on middle finger extension (P <0.05, analyzed by χ^2 test.).

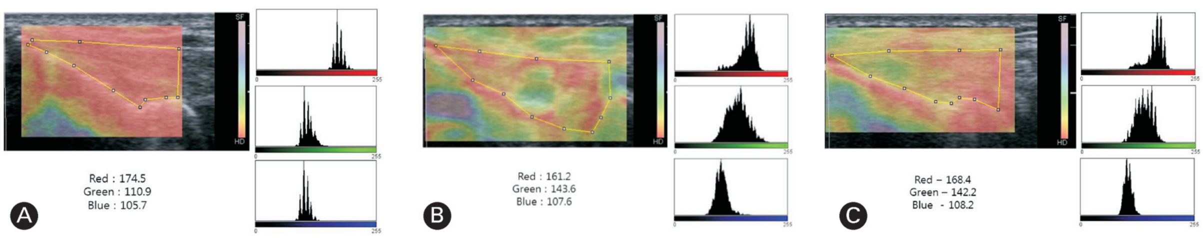

Figure 4. Representative longitudinal sonoelastographic images and color histograms of the common extensor tendon in asymptomatic **(A)** and symptomatic **(B, C)** elbows. Tendinosis and tear of the common extensor tendon on ultrasonographic examination were presented as B1 and B2, respectively. The color histograms were analyzed by using pixels in a polygon with a yellow margin; the mean pixel values±*SD* of each color are presented.

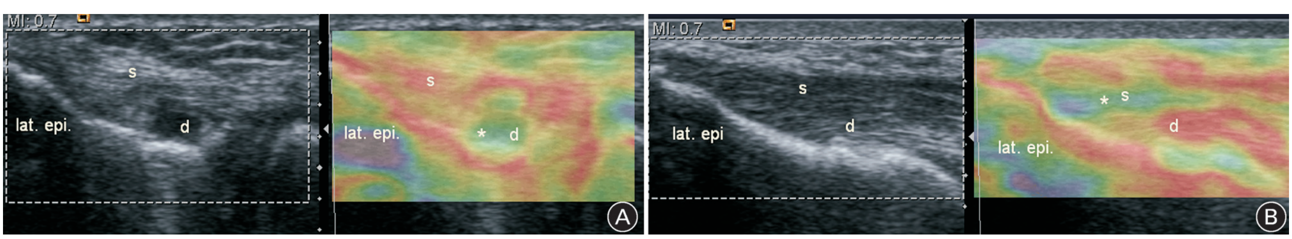

Figure 5. Longitudinal ultrasonographic and sonoelastographic findings of lateral elbow tendinopathy in the superficial **(A)** and deep **(B)** layers of the common extensor tendon. The stars represent areas of tendinopathy with sonoelastographic Score 1 or 2. lat. epi.=lateral epicondyle; s=superficial layer; d=deep layer.

hyperplasia.[14] In the chronic stage, recurrent degeneration and regeneration of the common extensor tendon cause weakness and increase the risk of rupture.[15] Pathologic tissue can be difficult to differentiate from a healthy tendon by conventional ultrasonography because the damaged tissue can have the same echogenicity as the surrounding tendon fibers.[16] In addition to the shape and vascularity data obtained by greyscale ultrasonography, sonoelastography can provide information about tissue elasticity, which is related to tendon pathology.[11] Therefore, evaluation of tissue elasticity may be a useful option for clarifying the severity of lateral elbow tendinopathy.

In this study, ultrasonography and sonoelastography displayed sensitivity of 89.3% and 96.4%, respectively, and specificity of 89.7% and 96.4%, respectively, in using clinical tennis elbow as a gold standard. These data are comparable to the results of a similar study by De Zordo et al.[10] However, the present study showed higher diagnostic values of ultrasonography than some previous studies of static ultrasonographic images, with sensitivity of 72%–88% and specificity of 36%–100%.[3,8,17] This discrepancy might be because ultrasonography is a dynamic, real-time diagnostic tool, with high operator dependency being its major disadvantage.

The diagnostic accuracy in this study was excellent for both ultrasonography and sonoelastography, but sonoelastography had better accuracy by 7.1% (Table 2). Further, the severity of the tendon pathology estimated by these methods was significantly correlated. Therefore, the diagnostic accuracy for lateral elbow tendinopathy can be improved if sonoelastography is performed simultaneously with real-time ultrasonography. In addition, the quantitative analysis showed objective interpretation of the sonoelastographic images (Figure 4). However, further research is required to clarify how the ROI is selected in the color histogram and the reference value of the normal tendon in the quantitative analysis.

The extensor muscles of the forearm can be divided into the superficial and deep groups. Four superficial extensors are attached by the common extensor tendon to the lateral epicondyle: extensor carpi radialis brevis (ECRB), extensor digitorum, extensor digiti minimi, and extensor carpi ulnaris.[18] Lateral elbow tendinopathy is clinically diagnosed from tenderness over the lateral epicondyle and pain on resistive extension of the wrist, which is the main function of the ECRB. However, the amount of hand and finger activities, such as using computers or smartphones, is increasing nowadays and there is a growing possibility of damage to the extensor digitorum or extensor digiti minimi. In this study, the abnormal ultrasonographic or sonoelastographic findings in the superficial layer of the common extensor tendon were significantly related to the clinical findings of pain over the lateral epicondyle on resistive middle finger extension. The interpretation is that the extensor digitorum tendon lies superficial to the ECRB tendon in the common extensor tendon. Unfortunately, the exact affected portion in the common extensor tendon is difficult to identify by conventional ultrasonography. However, if sonoelastography is used simultaneously, the injured fiber group will be easier to differentiate (Figure 5). Knowledge of the topography can provide further information on the pathology and patient's condition as well as enable education and treatment planning.

In this study, a low sonoelastographic score was correlated with long symptom duration, experience of steroid injection, and cortical irregularities around the lateral epicondyle (P <0.05). However, the sonoelastographic score was not significantly correlated with the subjective pain rating, fascial thickness of the tendon, and results of the power Doppler examination. Symptom duration, steroid use, and cortical irregularities may have some relationship with the chronicity of the tendon pathophysiology. Moreover, a soft tendon may result from the repeated degeneration and regeneration of the common extensor tendon. Therefore, sonoelastography can provide additional information to estimate the pathology of damaged tendons.

The experience of steroid injection was significantly related to findings such as a high subjective pain rating, long symptom duration, and increased vascularity in the power Doppler examination. This result might be explained by the fact that many subjects were referred from primary medical clinics, so some intractable cases were included in this study. Several clinical reports have demonstrated the limited efficacy of steroid injection for lateral elbow tendinopathy after 1 year.[19,20] The effect of steroid injection should be considered in further studies.

There are some limitations in this study. First, the imaging results were not compared with surgical or MR findings and only the clinical diagnosis was used as the standard of reference, which is not ideal and may lead to observational bias. Second, the imaging techniques depend greatly on the experience of the operator. Although the experienced physiatrist took great care to obtain reproducible scans, the intraobserver reliability was not calculated. Nevertheless, excellent interpretation of the sonoelastographic findings was achieved because of the quantitative analysis. Finally, a relatively small number of subjects were recruited in this study.

In conclusion, ultrasonography and sonoelastography are valuable for detecting alterations of the common extensor tendon in lateral elbow tendinopathy, with excellent sensitivity and specificity. Sonoelastography increases diagnostic confidence in tennis elbow pathology over greyscale ultrasonography alone and may be an additional powerful diagnostic tool in cases of lateral elbow tendinopathy with inconclusive greyscale ultrasonographic findings.

REFERENCES

1. Park GY, Lee SM, Lee MY. Diagnostic value of ultrasonography

for clinical medial epicondylitis. Arch Phys Med Rehabil 2008; 89: 738-742.
2. Coonrad RW, Hooper WR. Tennis elbow: its course, natural history, conservative and surgical management. J Bone Joint Surg Am 1973; 55: 1177-1182.
3. Levin D, Nazarian LN, Miller TT, O'Kane PL, Feld RI, Parker L, et al. Lateral epicondylitis of the elbow: US findings. Radiology 2005; 237: 230-234.
4. Bredella MA, Tirman PF, Fritz RC, Feller JF, Wischer TK, Genant HK. MR imaging findings of lateral ulnar collateral ligament abnormalities in patients with lateral epicondylitis. AJR Am J Roentgenol 1999; 173: 1379-1382.
5. Martin CE, Schweitzer ME. MR imaging of epicondylitis. Skeletal Radiol 1998; 27: 133-138.
6. Miller TT, Shapiro MA, Schultz E, Kalish PE. Comparison of sonography and MRI for diagnosing epicondylitis. J Clin Ultrasound 2002; 30: 193-202.
7. Connell D, Burke F, Coombes P, McNealy S, Freeman D, Pryde D, et al. Sonographic examination of lateral epicondylitis. Am J Roentgenol 2001; 176: 777-782.
8. Struijs PA, Spruyt M, Assendelft WJ, van Dijk CN. The predictive value of diagnostic sonography for the effectiveness of conservative treatment of tennis elbow. AJR Am J Roentgenol 2005; 185: 1113-1118.
9. Khoury V, Cardinal E. "Tenomalacia": a new sonographic sign of tendinopathy? Eur Radiol 2009; 19: 144-146.
10. De Zordo T, Lill SR, Fink C, Feuchtner GM, Jaschke W, Bellmann-Weiler R, et al. Real-time sonoelastography of lateral epicondylitis: comparison of findings between patients and healthy volunteers. Am J Roentgenol 2009; 193: 180-185.
11. Park GY, Kwon DR. Application of real-time sonoelastography in musculoskeletal diseases related to physical medicine and rehabilitation. Am J Phys Med Rehabil 2011; 90: 875-886.
12. Suresh SP, Ali KE, Jones H, Connell DA. Medial epicondylitis: is ultrasound guided autologous blood injection an effective treatment? Br J Sports Med 2006; 40: 935-939; discussion 939.
13. Kwon DR, Park GY. Diagnostic Value of real-time sonoelastography in congenital muscular torticollis. J Ultrasound Med 2012; 31: 721-727.
14. Nirschl RP. Elbow tendonosis tennis elbow. Clin Sports Med 1992; 11: 851-870.
15. Nirschl RP, Pettrone FA. Tennis elbow. The surgical treatment of lateral epicondylitis. J Bone Joint Sur Am 1979; 61: 832-839.
16. Frey H. Realtime elastography. A new ultrasound procedure for the reconstruction of tissue elasticity (in German). Radiologe 2003; 43: 850-854.
17. Maffulli N, Regine R, Carrillo F, Capasso G, Minelli S. Tennis elbow: an ultrasonographic study in tennis players. Br J Sports Med 1990; 24: 151-155.
18. Moore KL, Dalley AF. Clinically oriented anatomy. 4th ed. Philadelphia: Lippincott Williams & Wilkins; 1999.
19. Bisset L, Beller E, Jull G, Brooks P, Darnell R, Vicenzino B. Mobilisation with movement and exercise, corticosteroid injection, or wait and see for tennis elbow: randomised trial. BMJ 2006; 333: 939-941.
20. Peerbooms JC, Sluimer J, Bruijn DJ, Gosens T. Positive effect of an autologous platelet concentrate in lateral epicondylitis in a double-blind randomized controlled trial platelet-rich plasma versus corticosteroid injection with a 1-year follow-up. Am J Sports Med 2010; 38: 255-262.

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