Chapter

Assessment of De Quervain Tenosynovitis Patients with Strain-Based Elastography

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Abstract

Elastography was introduced to clinical practice almost two decades back, to further enhance ultrasound imaging for illustrating the difference in mechanical properties between diseased and healthy tissues, i.e., difference in tissue stiffness, in a qualitative and quantitative way. In the nineteenth century, Fritz De Quervain reported patients with pain and swelling at the wrist. It is an entrapment condition of the tendons within the first extensor compartment. The advantages of ultrasound (U/S), in general, is being a rapid bed-side test, low cost, availability, and great patient compliance all of which elastography makes use of. Elastography imaging for liver fibrosis assessment is a well-known technique; yet recent territories for tissue elasticity assessment are emerging. One of these large territories is muscle tendons elasticity assessment in different pathologic conditions. One of these areas is changes in tendons stiffness. Fifty-two subjects were studied, 30 diseased and 22 healthy. The main complaint of the diseased group was pain at the radial side of the wrist, while healthy subjects were symptom free. Sensitivity was 92%, while specificity was 93%. From my work, I reached the conclusion of that the disease can be diagnosed with strain-based elastography in a quantitative way with confidence and reliability.

Keywords: ultrasound, elastography, strain-based elastography, strain elastography, wrist joint, De Quervain tenosynovitis

1. Introduction

Elastography was introduced to clinical practice almost two decades back, to further enhance ultrasound imaging [1] and illustrate the difference in mechanical properties between diseased and healthy tissue [2], i.e., difference in tissue stiffness, in a qualitative and quantitative way. The basic idea of elastography is to take advantage of the changed tissue elasticity/stiffness during tissue disease as compared to adjacent similar normal tissues.

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Elastography imaging for liver fibrosis assessment is a well-known technique; yet recent territories for tissue elasticity assessment are emerging. One of these large territories is muscle tendons elasticity assessment in different pathologic conditions. One of these areas is changes in tendons stiffness.

In the nineteenth century, Fritz De Quervain reported patients with pain and swelling at the wrist. It is an entrapment condition (tendon inflammation) of the

tendons within the first extensor (dorsal) compartment of the wrist back of the wrist; patients suffered pain during motion of the thumb. The tenosynovitis affects the abductor pollicis longus (APL) and the extensor pollicis brevis (EPB) tendons-muscle tendons at the back of the wrist [3].

Anatomically, the first extensor compartment of wrist joint is lying between the radial styloid process and the base of the thumb, containing two muscle tendons: the abductor pollicis longus (APL).

De Quervain disease is considered the second most common tendon entrapment condition after trigger finger. Because of repeated trauma, the first dorsal extensor compartment tendons thicken, hindering their gliding through the tight fibro-osseous tunnel.

In B-mode ultrasound scan of the first dorsal compartment, we can find one or more of the following criteria: fluid collection, thickening of tissues, or tissue edema. Colored Doppler application to the tissue under investigation shows increased blood flow to the area.

2. Elastography techniques

Tissue elasticity is assessed with ultrasound tissue elastography. Elasticity of a tissue is its tendency to resist deformation when applying force the tissue in question, or regaining its original shape after cessation of the force. The idea of elastography is based on assuming that the tissue under examination is entirely elastic and has no viscosity [4].

Two main techniques are developed to measure tissue elasticity quantitatively using ultrasound machines:

1. Strain technique: apply normal stress to the tissue and the normal strain of the tissue is calculated; where tissue strain is its ability to expand after removal of the stress [4].

2. Shear-wave technique: a dynamic stress applied to the tissue under examination using different techniques to apply such a dynamic stress, and the tissue strain is calculated [4].

3. Strain technique

Strain technique is first to evolve between the two techniques mentioned above, and it uses two methods for strain calculation: either strain elastography or acoustic radiation force impulse (ARFI). What we are concerned here is about the first method, i.e., strain elastography.

Strain elastography can be achieved by two methods of excitation:

1. Manual compression by the operator using the ultrasound transducer; provided that the examined tissue is superficial.

2. No manual compression; where tissue displacement occur physiologically with internal organs as cardiovascular or respiratory systems, hence deeper structures could be studied.

What we are concerned with here is manual compression that is explained in details later on.

4. Tsukuba score for tissue elasticity

Tsukuba elasticity score is a 1–5 score scale; built upon a map of stiffness of tissues in and around the pathologically affected segment, and the score calculated based upon the stiffness of the lesion in relation to the surrounding tissues.

a. Lesions scored (1): lesion has less or equal stiffness to surrounding tissues;

b. Lesions scored (2): lesion has mixed areas of stiffness;

c. Lesions scored (3): lesion is stiffer than surrounding tissue, and on elastogram has lesser size than B-mode ultrasound;

d. Lesions scored (4): lesion is stiffer than the surrounding tissue, and on elastogram has same size as B-mode ultrasound; and

e. Lesions scored (5): lesion is stiffer than the surrounding tissue, and larger on elastogram than B-mode ultrasound.

5. Study goal

My hypothesis was that with the pathological changes in the first extensor compartment tendons of the wrist by virtue of the disease, we could use the Tsukuba score for tissue elasticity [5] to quantitatively assess the elasticity or hardness of the affected tendons.

6. Ultrasound and strain-based elastography examination technique

Ultrasound examinations performed using Philips IU22 xMatrix machine (Philips Ultrasound, Bothell, WA, USA) with linear transducer (12–15 MHz). Advanced small parts option and elastography QLAB were used.

The patient positioned in sitting at the edge of the examination couch with legs dependent, i.e., both knees flexed at right angle with forearm under examination positioned over the ipsilateral thigh in pronation with a clean plastic sheet in between the thigh and forearm of the patient.

B-mode ultrasound examination of the compartment retinaculum and tendons performed at the start to scrutinize the full spectrum of the lesion in transverse and longitudinal views.

Strain-based elastography was then performed by applying controlled pressure over the compartment guided by colored column on screen of ultrasound machine to achieve the proper pressure amount for strain-based elastography calculation by the machine.

Strain-based elastography mean and standard deviation calculations readings are then displayed.

Three strain-based elastography readings are taken for the patient and averaged to calculate the final reading, which will be used to diagnose the condition.

7. The problem

The condition is an entrapment syndrome.

8. Anatomy

The first extensor compartment of wrist joint is lying between the radial styloid process and the base of the thumb, containing two muscle tendons: the abductor pollicis longus (APL), which is inserted into the base of the first metacarpal bone, or into trapezium bone and extensor pollicis brevis (EPB), which is inserted into the proximal phalanx of the thumb [6].

The APL and EPB muscle tendons with their synovial sheets travel under the extensor retinaculum, which are attached to radial styloid forming tight fibro-osseous tunnel.

9. Epidemiology

De Quervain tenosynovitis is considered the second most common tendon entrapment condition after stenosing tenosynovitis-trigger finger [7].

The condition occurs in middle-aged persons with 3:1 female to male ratio [7].

The condition occurs by the virtue of repetitive wrist movement associated with thumb radial abduction with wrist extension and radial wrist deviation [8].

The classic populations are mothers and childcare workers; however, secretaries and nurses much presented [7, 8]. Other populations affected are golf players or frequent hammer users [9, 10].

Modern life style escalated the incidence of De Quervain tenosynovitis because of computer and cellular phones excessive use [11].

10. Clinical presentation

Main patient complaint is pain and swelling over the styloid process of the radius [12].

On examination, swelling and tenderness over radial styloid found. Crepitus and triggering may be also found [12].

Finkelstein's test, the clinical test examination, involves flexion of the meta-carpophalangeal joint of the thumb in a closed hand followed by ulnar deviation passively of the wrist joint can replicate the pain at radial styloid [9, 12].

11. Pathology

Because of repeated trauma, the APL and EPB tendons thicken, hindering their gliding through the tight fibro-osseous tunnel [13, 14].

Pathologically, the tendons are thickened by virtue of degenerative changes such as myxoid degeneration, deposition of mucopolysaccharides, and fibrocartilag-enous metaplasia [13, 14].

Hence, it is a misnomer to call the condition tenosynovitis, as the pathological changes do not involve tendons inflammation [15].

12. B-mode ultrasound findings

Several findings could be detected in B-mode ultrasound scan of the first dorsal compartment prior to strain-based elastography application; these findings include [16]:

- Fluid collection in the tendon sheaths (**Figure 1**).
- Thickened overlying retinaculum.
- Thickened synovial sheaths (**Figure 2**).
- Thick edematous tendons of APL and EPB (**Figure 3**) at level of styloid process of the radius (compared with contralateral side).
- Halo sign; due to edema in the tissues surrounding the tendons.
- Doppler application reveals hyperemia surrounding the tendons.

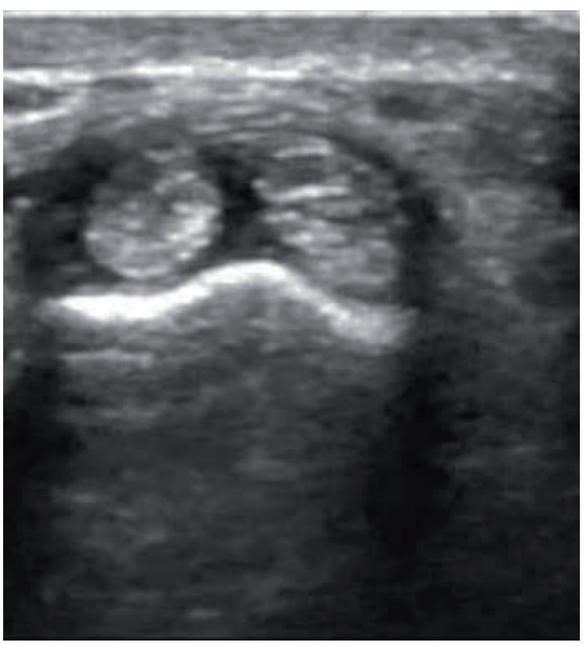

Figure 1.
Fluid collection in the synovial sheaths of APL and EPB muscle tendons in transverse ultrasound image of a patient with De Quervain tenosynovitis.

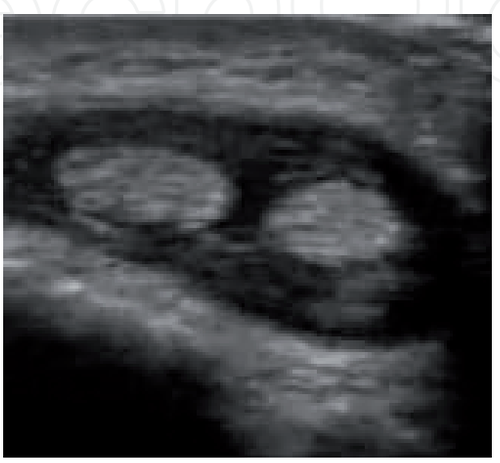

Figure 2.
Thickened synovial sheaths of APL and EPB muscle tendons with fluid collection in tendon sheath in transverse ultrasound image of a patient with De Quervain tenosynovitis.

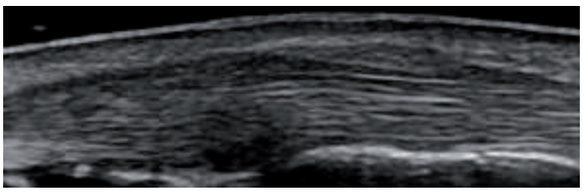

Figure 3.
Thick edematous tendon of APL muscle in longitudinal ultrasound image of a patient with De Quervain tenosynovitis.

Index	Percentage (%)
PPV	95
NPV	90
Sensitivity	92
Specificity	93

Table 1.
Strain-based elastography indices.

Number of subjects	Strain-based elastography ratio
28 patients	1–3.5
2 patients	4.2–6
20 volunteers	6.1–9.2
2 volunteers	2–3.9

Table 2.
Strain-based elastography ratios in De Quervain tenosynovitis patients and volunteers.

13. Current study

Fifty-two subjects were studied; 30 diseased comprised group 1 and 22 healthy comprised group 2.

The main complaint of the diseased group was pain at the radial side of the wrist with positive Finkelstein test, while healthy subjects were symptom-free with negative Finkelstein test.

There was no significant difference ($p > 0.01$) between groups in regards to age and sex.

Strain-based elastography indices are illustrated in **Table 1**.

The mean elastography value for the diseased was 2.3; while for healthy subjects, it was 6.1 with statistically significant difference between the two groups ($p < 0.001$). For strain ratio details, refer to **Table 2**.

The threshold for diagnosing De Quervain disease was 4.

B-mode ultrasound findings displayed in **Table 2** [3].

14. Discussion

In De Quervain tendinopathy tendon increased cross section, increased water content of the tendons, abnormal degenerative materials deposited, and changes in collagen fibers properties all lead to changes of the elastic characteristics of the tendons with consequent softening of the affected tendons [17].

In my work, I found lower sensitivity (92%) than specificity (93%) for the quantitative assessment of the disease, in accordance with the remarks of Sébastien Aubry studying the Achilles tendinopathy with shear-wave elastography [18].

De Zordo et al. [19] stated that normal Achilles tendons show hard consistency as compared to diseased tendons, going with my work results of 6.1 elastography mean value for healthy subjects and 2.3 for diseased. Moreover, Dirrichs et al. [20] studied epicondylar, Achilles, and prepatellar pathologic tendons and found that the diseased tendons returned decreased elastography values as compared to healthy volunteers regardless of anatomical location.

In my study, I found statistically significant difference ($p < 0.001$) between healthy and diseased subjects in regards to elastography readings in accordance with Chen and coworkers concluding that elastography is an important tool for mechanical information assessment of Achilles function [21].

In two healthy subjects, we found low strain ratio, which could be explained by the fact that they were having subclinical tenosynovitis as postulated by De Zordo et al. [22].

Moreover, not possibly to explain the three diseased tendons showing high elastography values except for one patient with cyst formation under the retinaculum raising the tension inside the compartment.

More study is needed for the true benefit of strain-based elastography of the condition comparing the results with histopathological specimens—if possible—of the affected tendons, for a definitive proof of the presence or absence of the disease and the state of progression of the disease.

15. Conclusion

We can conclude that the disease can be diagnosed with strain-based elastography in a quantitative way with confidence and reliability.

Conflict of interest

The author declares no conflict of interest financially or personally with any institution, organization, or persons.

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References

[1] Prker KJ, Huang SR, Musulin RA, Lerner RM. Tissue-response to mechanical vibrations for sonoelasticity imaging. Ultrasound in Medicine & Biology. 1990;**16**:241-246

[2] Doyley MM, Parker KJ. Elastography: General principles and clinical applications. Ultrasound Clinics. 2014;**9**(1):1-11. DOI: 10.1016/j.cult.2013.09.006

[3] Ghandour AM, Ghandour TM. Strain-based elastography assessment of patients with De Quervain tenosynovitis: A preliminary study. The Egyptian Journal of Radiology and Nuclear Medicine. 2018;**49**:415-418

[4] Sigrist RMS, Liau J, El Kaffas A, Chammas MC, Willmann JK. Ultrasound elastography: Review of techniques and clinical applications. Theranostics. 2017;**7**(5):1303-1329. DOI: 10.7150/thno.18650

[5] Itoh A, Ueno E, Tohno E, Kamma H, Takahashi H, Shiina T, et al. Breast disease: Clinical application of US elastography for diagnosis. Radiology. 2006;**239**:341-350

[6] Hazani R, Engineer NJ, Cooney D, Wilhelmi BJ. Anatomic landmarks for the first dorsal compartment. Eplasty. 2009;**8**:6-11

[7] Zanzoni A. Mint: A molecular interaction database. Journal of Microbiology. 2002;**513**:135-140. DOI: 10.1016/s0014-5793(01)03293-8

[8] Satteson E, Shruti C. Tannan: De Quervain tenosynovitis. In: StatPearls. Treasure Island (FL): StatPearls Publishing; 2019

[9] Ritu G, Abzug Joshua M. De Quervain's tenosynovitis: A review of the rehabilitative options. Hand (N Y). 2015;**10**(1):1-5

[10] Jaworski CA, Krause M, Brown J. Rehabilitation of the wrist and hand following sports injury. Clinics in Sports Medicine. 2010;**29**(1):61-80. DOI: 10.1016/j.csm. 2009.09.007

[11] Ali M, Asim M, Danish SH, et al. Frequency of De Quervain's tenosynovitis and its association with SMS texting. Muscles Ligaments Tendons Journal. 2014;**4**(1):74

[12] Stoller DW, Tirman PF, Bredella MA. Diagnostic imaging, Orthopaedics. Amirsys Inc; 2004. ISBN: 0721629202

[13] Cyriac P-V, van der Windt DAWM, Winters Jan C, Betty M-d J, Cochrane Musculoskeletal Group. Corticosteroid injection for de Quervain's tenosynovitis. Cochrane Database of Systematic Review; 2009. DOI: 10.1002/14651858. CD005616.pub2

[14] Min CJ, Jae-Kyung W, Kyoung-Bun L, In Ae P, Ann Y, Kyung MW. Comparison of shear-wave and strain ultrasound elastography in the differentiation of benign and malignant breast lesions. AJR. 2013;**201**:W347-W356

[15] Clarke MT, Lyall HA, Grant JW, Matthewson MH. The histopathology of de Quervain's disease. Journal of Hand Surgery (British). 1998;**23**(6):732-734

[16] Diop AN, Ba-Diop S, Sane JC, et al. Role of US in the management of de Quervain's tenosynovitis: Review of 22 cases. Journal de Radiologie. 2008;**89** (9 Pt 1):1081-1084

[17] Cortes Daniel H, Suydam Stephen M, Grävare SK, Buchanan Thomas S, Elliott Dawn M. Continuous shear wave elastography: A new method to measure in-vivo viscoelastic properties of tendons. Ultrasound in Medicine & Biology. 2015;**41**(6):1518-1529

[18] Sébastien A, Jean-Philippe N, Mickaël T, Fabio B, Chrystelle V, Fabrice M. Viscoelasticity in achilles tendinopathy: Quantitative assessment by using real-time shear-wave elastography. Radiology. 2015;**274**(3)

[19] Tobias DZ, Christian F, Feuchtner Gudrun M, Vinzenz S, Markus R, Sabine KA. Real-time sonoelastography findings in healthy achilles tendons. AJR. 2009;**193**:W134-W138

[20] Dirrichs T, Quack V, Gatz M, et al. Shear wave elastography (SWE) for the evaluation of patients with tendinopathies. Academic Radiology. 2016;**23**(10):1204-1213

[21] Chen XM, Cui LG, He P, et al. Shear wave elastographic characterization of normal and torn achilles tendons a pilot study. Journal of Ultrasound in Medicine. 2013;**32**(3):449-455

[22] De Zordo T, Chhem R, Smekal V, et al. Real-time sonoelastography: Findings in patients with symptomatic achilles tendons and comparison to healthy volunteers. Ultraschall in der Medizin. 2010;**31**(4):394-400