The possibilities of ultrasonic shear-wave elastography in assessing the effectiveness of conservative treatment of achillitis

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Abstract. The share wave elastography (SWE) is the new ultrasound diagnostics method which makes possible to measure the tissue stiffness (elasticity). But the ability of SWE is not widely uses in cases of musculoskeletal diseases, including tendinoopathy. American scientists dealing with tendinopathy found that due to degeneration and disorganization of the collagen structure, changes in the content of proteoglycan and water, fat infiltration and neovascularization, the elasticity of the Achilles tendon decreases according to ultrasound sonoelastography. However, these authors did not analyze the timing of restoring the elasticity of the tendon fiber, and did not compare the ultrasound picture of the grayscale mode and ESV indicators.

Keywords: ultrasonic shear-wave elastography, achillitis

Introduction

In the last decade, a new technology – elastography-has appeared in the practice of ultrasound diagnostics (ULTRASOUND) [9, 10, 15, 20, 22, 43, 47]. This term was first proposed by Ophir et al. (USA)in 1991 [9, 36] and designated a method for differentiating tissues by the elasticity of the material, the physical basis of which is the determination of the Young's modulus, which characterizes the resistance of tissues in response to their stretching / compression. To date, there are two types of elastography: compression and shear wave (shear wave).

Compression elastography – RTE) is a method for qualitative assessment of elastic properties of tissues by the equation $E=\sigma/\varepsilon$. In the course of the study, the sensor is dosed to compress the area under study, followed by a comparison of the obtained indicators from individual sites in the field of interest. The image on the elastogram is the result of analysis, processing and "superimposition" of two echograms obtained in B-mode: before compression and after pressure on the tissue. As a result, the elasticity of the tissues is displayed on the screen in certain colors [15]. The method has been successfully implemented in practice for the detection of pathological formations in the mammary, thyroid, prostate glands, lymph nodes, and in endosonographic studies of the pancreas [2, 28, 37]. At the same time, compression elastography does not allow us to estimate the elasticity of any particular area in absolute numerical values, it is necessary to compare the area of interest with the unchanged tissue, there are difficulties with the standardization of the methodology and the reproducibility of the data. Due to the above circumstances, RTE is not used in orthopedics and traumatology [17, 37].

To eliminate the shortcomings of compression elastography, biophysicist A. P. Sarvazyan developed a method called SWE or shear wave ultrasound elastography (ESW) [17, 18, 19, 20]. The displacement of the medium particles and the accompanying deformation of the tissue occur in the transverse direction relative to the direction of wave propagation [15]. ESW is a method for quantifying the elasticity of tissues based on the calculation of the velocity of propagation of a transverse (shear) wave. The Young's modulus is determined by the equation E=3 x p x C2, where p is the density of the substance in kg / m3, and C is the shear wave velocity in m/s. It should be noted that the speed indicators are directly proportional to the indicators of the elasticity of the fabric [1, 3, 5, 17, 49, 50]. In practical health care, ESV appeared in 2008 and was initially used in gastroenterology [1, 3, 5, 9, 13, 16, 24, 28 37, 48], oncology [6, 7, 10, 14, 23, 26, 28, 37], later – in endocrinology [7, 8], urology and gynecology [4, 11, 28, 37]. However, in rheumatology, traumatology and orthopedics, studies using ESV began only in 2013. and they were devoted exclusively to determining the value of the Young's modulus of the unchanged Achilles tendon [32, 33], as the most accessible anatomical object for studying, and the presence at that time of linear ultrasound sensors with the ability to reproduce ESV with a frequency not exceeding 7.5 MHz.

As a result of active research in the framework of a pilot project in the United States, it was found that the normal elasticity of the achilles tendon is 291.91±4.38 kPa [31], which was later confirmed by the data of Zhang (2014) – 289.6±23.4 kPa and Jeong Ah Ryu, Woo Kyo Jeong (2017) - 280-400 kPa. At the same time, some authors argued that it is more correct to analyze the elasticity of the tissue, expressed not in kPa, but in m/s, proving that the wave propagation velocity in the range of 1-10 m/s corresponds to the tissue elasticity from 1 to 300 kPa (Youk et al., 2014). This version is also followed by Ahn K.-S., Kang C. H., Hong S.-J., Jeong W.-K. (2014), Xiang-Mei Chen, Li-Gang Cui, Ping He (2019). The values of the shear wave propagation velocity in the unaltered tendon presented by them were 7.91 m / s – 9.56 m/s±0.27-0.5 m / s.

Further study of the possibilities of ESV in traumatology showed that the parameters of the elasticity of tendon fibers depend on the degree of tension of the fibrils. If in the relaxed state, the normal shear wave velocity of the unchanged tendon is 15.55 m/s in the sagittal orientation and 5.29 m/s in the transverse (axial) orientation, then when the limb is flexed, these indicators change and correspond to 7.03 m/s and 4.76 m / s [33, 42]. Thus, in order to standardize the ESV technique and ensure the reproducibility of quantitative results of assessing the elasticity of the Achilles tendon, American scientists at the University of Carolina proposed two options for its implementation: in the relaxation position (the patient lies on his stomach, the leg in the ankle joint hangs from the edge of the couch) and in the position of fixing the foot with the knee joint bent at 90°. At the same time, the ESV indicators in these methods differ in the range of 2-4%, which, according to Eby et al. (2013) and Aubry (2015), due to the peculiarity of the location of collagen fibers inside the tendon and do not have a significant statistical error.

Of course, the information obtained during ESV required the creation of an evidence base and reference diagnostic methods: they were MRI and histological examination. Over the next four years of development, it was shown that changes in the elasticity of tendon fibers are registered earlier than morphological changes, i.e. ESV detects violations in the structure of the tendon matrix and identifies pathology earlier than B-mode ultrasound and MRI [37, 38, 40, 46]. This is especially clearly demonstrated in the works of B. Frankewycz (2017, 2020), T. X. Haen (2017), B. K. Coombes (2018).

A certain clinical interest among traumatologists and orthopedists is caused by the possibility of diagnostic monitoring of the condition of the Achilles tendon during the treatment of achillitis. Achillitis is a disease of the achilles tendon of an inflammatory nature, accompanied by a violation of the function of the lower limb. The frequency of its occurrence in the population in the age group of 25-45 years is from 9 to 11 % [25]. In 20% of cases, the disease is bilateral in nature [25]. In the treatment of tendon disease, conservative methods are usually used. The most common and effective measures, according to a number of Russian experts, are considered therapeutic blockades with the use of corticosteroids [20]. However, 40.9% of patients relapse at various times [25]. As a rule, if the therapy is unsuccessful, a variety of surgical interventions are used. At the same time, surgical treatment options cannot be considered ideal, since the developing scarring process in the tissues and subsequent mechanical disorders can reflexively support the secondary pain syndrome for a long time [25].

Diagnosis of achillitis is not clinically difficult. To confirm the diagnosis and detail changes in the area of Achilles tendon enthesis, ultrasound in B-mode, color-coded techniques, and MRI are used to the calcaneus. With the help of these methods, the effectiveness of the conservative treatment and the complete regression of inflammation are also evaluated. However, in this case, the question arises: if the patient with adequate therapy, initiated in the early stages of the disease, the absence of any morphological disorders in the tendon structure at the time of the pathology, professional dynamic control by specialists of traumatologists-orthopedists and ultrasound doctors, relapse occurs, then, apparently, the existing medical and diagnostic control of the treatment of achillitis is not perfect?

A partial answer to this question was obtained in the works of Arda (2011), Chen (2013), Horton (2013) and Fu (2016) dealing with tendinopathy, which found that due to degeneration and disorganization of the collagen structure, changes in the content of proteoglycan and water, fat infiltration and neovascularization, the elasticity of the Achilles tendon decreases. However, the authors did not analyze the terms of restoring the elasticity of the tendon fiber, and did not compare the ultrasound picture of the seroscale regime and ESV indicators. In this regard, the aim of our study was to compare the dynamics of regression of inflammatory changes in the Achilles tendon in the B-mode with the data of ultrasonic elastometry by the shear wave method.

Purpose of the study – to compare the dynamics of regression of inflammatory changes of the Achilles tendon in B-mode with the data of ultrasonic elastometry using the shear wave method.

Materials and methods

We examined 26 patients (21 men, 5 women) who were on hospital treatment, with the established diagnosis of "achillitis" at the age of 18 to 34 years. The duration of the disease did not exceed 2 weeks. All patients underwent triple ultrasound of the Achilles tendon (at the time of admission to the hospital, 1 and 2 weeks after the start of anti-inflammatory therapy) on the LG Logic S8 device with a linear sensor L9. the assessment of the elasticity of tendon fibers was performed in the area of the most pronounced inflammatory changes with the determination of the young's modulus, expressed in KPa. MRI was performed twice on a Siemens Magnetom Aera 1.5 TL machine (at the time of hospitalization and when the achillitis clinic disappeared). CT was performed three times on the device Toshiba Prime Aguilioi 160 according to standard methods.

Results and discussion

All patients with ultrasound in B-mode at the time of hospitalization showed a decrease in the echogenicity of tendon fibers with a moderate violation of their differentiation in the middle (76.9%) or distal (23.1%) parts of the Achilles tendon as a result of edema. The zone of inflammatory changes was localized in the Central parts of the tendon in 25.7%, in the peripheral parts-in 74.3%. In elastometry, the young modulus of the fibers was 105.5 ± 16.5 KPa. With a decrease in the clinical activity of the inflammatory process against the background of normalization of the echographic picture of the tendon, the values of the young's modulus of fibers were preserved in the range of 113.95 ± 3.95 kPa.

After 14 days from the start of conservative therapy, when the clinical manifestations of achillitis subsided and the Achilles tendon was restored to the unchanged ULTRASOUND picture, an increase in fiber elasticity to 171.85 ± 17.45 kPa was observed. Ultrasound data in assessing the condition of tendon fibers were confirmed by MRI, elasticity-by CT results with densitometry. However, according to the ESV data, there was no complete recovery of unchanged parameters of tendon elasticity (in 92.4% of the examined patients).

Ultrasound in combination with ESV 21 days after hospitalization and the beginning of treatment showed that only by this time there was a complete restoration of the elasticity of the Achilles.

Conclusion

Shear wave elastography is reliable (according to experimental and analytical methods) in determining the zone of inflammatory changes. The data of elastometry assess the effectiveness of conservative treatment of agilita. Residual manifestations of inflammation according to elastometry persist for 5-6 days after normalization of the echographic picture of the Achilles tendon and require an increase in the period of treatment of achillitis.

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