HOW USEFUL IS ELASTOGRAPHY IN THE FOLLOW-UP OF ACHILLES TENDON REPAIR?

ABSTRACT

Introduction: In addition to conservative modalities in the treatment of Achilles tendon injuries, open, percutaneous and minimally invasive semi-open techniques, as well as biological open surgical repair methods are used as surgical options. Compression elastography is one of the methods used for the follow-up of treatment in Achilles tendon injuries. Methods: 23 patients were included in our study between July 2013 and June 2014, as long as they had at least 4 years of follow-up. In the final control, the intact side and the operated side were both examined and compared. The variables were the American Orthopedic Foot and Ankle Score (AOFAS) which is measured as a functional score considering plantar flexion and dorsiflexion; calf circumference; Achilles tendon anteroposterior (AP) diameter; and elastographic examination. Results: The strain ratio value and AP diameter of the patients was significantly higher on the operated side than on the non-operated side (p <0.001). There was no significant difference between the plantar flexion and dorsiflexion degrees on the operated side of the patients (p> 0.05). No correlation was observed between strain ratio and AOFAS (p> 0.05). Conclusion: Elastography is not a useful technique to evaluate functional results on long-term tendon healing. Level of Evidence III; Retrospective comparative study.

Keywords: Achilles tendon. Tendon Injuries. Elasticity Imaging Techniques.

INTRODUCTION

Achilles tendon is one of the most frequently injured tendons in the human body.1 The tendon is mainly formed by parallel structured type 1 collagen. The amount of type 3 collagen fibers increases during the healing period and the tendon becomes a heterogeneous structure.2 As a result of this fibrosis, the tendon becomes stiffer and has reduced elasticity.3 In addition to conservative modalities in the treatment of Achilles tendon injuries; open, percutaneous, minimally invasive semi-open techniques and biological open surgical repair method defined by Arslan et al. are available as surgical options.4 Ultrasound-dependent methods used in the follow-up of the treatment are preferred because they are easily accessible,
quick and low cost methods. There are two main techniques in the elastographic method, which are compression elastography and shear-wave elastography. Compression elastography (Figure 1) is a qualitative or semiquantitative method based on the application of compression waves to the tissue. The practitioner performs rhythmic and regular compressions to obtain an axial tension in the relevant area. When a certain amount of stress is applied, flexible tissues undergo more deformation, resulting in more tension than hard tissues.

The aim of the study is to evaluate the long-term results of Achilles tendon rupture cases operated with biological open surgical repair in terms of functional and elastographic aspects and to examine the correlation between them.

MATERIAL AND METHODS

This study was conducted in accordance with the ‘Declaration of Helsinki and approved by the ethics committee of authors’ previous affiliated institution. Approval number: 16.9.15.30. Patients between 18-50 years old who underwent biological open surgical repair for traumatic Achilles tendon rupture between July 2013 and June 2014 with at least 4 years follow-up were included in our study. Patients with previous ankle fracture or ankle arthritis, diabetes mellitus and rheumatoid arthritis, as well as any Achilles tendinopathy, collagen tissue disease or infection in the postoperative period and those who did not come to the final control were excluded. Finally, 23 patients between 28-46 years old were included in the study. The same surgical method was applied to all patients by the same surgeon. Short leg circular cast in 25°-30° plantar flexion was applied to all the patients postoperatively and was kept in place until the sutures were removed. The daily wound care was performed through the plaster window opened from the incision line. The plaster was removed at the second week and the same position was maintained with range of motion (ROM) walker without weightbearing. Starting from the third week, partial weightbearing was initiated. In full active plantar flexion, dorsiflexion was increased by 10° degrees weekly and normal ankle ROM was achieved after eight weeks. After the eight week, full weightbearing and active Achilles stretching exercises were started. In the last control, while the patients were lying in the prone position, the foot hanging over the edge of the examination (Table 1), in a fixed neutral dorsiflexion position. The tendons were evaluated axially and longitudinally by a radiologist. Apart from this, measurements were made with the help of a probe holder to prevent differences in the probe’s grip. In this procedure, the calculation of tissue elasticity distribution was performed in real-time and the examination results were represented on an acolor map superimposed on the B-mode image. The color represented the relative stiffness of the tissues within the region of interest and ranged from blue (stiff) to red (soft) in the spectrum. Green and yellow indicated medium stiffness. The Achilles tendon was compressed with the same pressure. Real-time sonoelastographic scans were repeated by compression and relaxation of the scan area for at least four cycles so that findings could be verified as reproducible. The Achilles tendons with elastographic image evaluation were divided into the following thirds: proximal (musculotendinous junction), middle (2–6 cm above insertion at the calcaneus), and distal (insertion at the calcaneus). Central part of the Achilles tendon in the 2-6 cm proximal of calcaneal insertion point were selected for review and evaluated in the longitudinal plane. Localized Kager fat plan posterior to the tendon was selected for strain ratio. The operative tendon and intact tendon of each patient were measured.

RESULTS

The average age of the patients was 34.35 ± 6.47 years and the mean follow-up period was 61.74 ± 5.72 months. The operation side is on the right side in 13 patients (56.5%) (Table 2). The measurements between operated side of the patients and the measurements on the intact side were evaluated as independent groups. The AP diameter value (median: 6.80) of the patients on the operated side was significantly higher than the non-operated side (median: 3.50) (p < 0.001) (Figure 2). The strain ratio value (median: 7.88) of the patients on the operated side was significantly higher than the non-operated side (median: 1.51) (p < 0.001) (Figure 3). There was no significant difference between the plantar flexion and dorsiflexion values of the patients (p > 0.05). However, the calf circumference (mean: 36.98 ± 2.97) on the operated side was significantly lower than the non-operated side (mean: 37.59 ± 2.89) (p: 0.039) (Figure 4). When the correlation between the age, follow-up time, AOFAS, AP diameter difference and strain ratio difference was examined; there was a moderate negative correlation between age and follow-up period (r: -0.431, p: 0.040). Most importantly, no correlation was observed between strain ratio and AOFAS in patients (r: -0.001 p: 0.995) (Table 3).

![Figure 1. Comparative elastographic examination of the patients’ intact and operated sides.](image-url)
Achilles tendon is the strongest and the most frequently injured tendon of the body. As a result of injury, the mechanical properties of the tendon and lower extremity functions may vary. Surgical repair and rehabilitation is accepted to be the standard treatment for providing the original mechanical properties of the tendon.\textsuperscript{10}

DISCUSSION

Achilles tendon is the strongest and the most frequently injured tendon of the body. As a result of injury, the mechanical properties of the tendon and lower extremity functions may vary. Surgical repair and rehabilitation is accepted to be the standard treatment for providing the original mechanical properties of the tendon.\textsuperscript{10}

There are open, minimally invasive and percutaneous techniques described for the surgical treatment. In the literature, there are articles stating that the open technique is better;\textsuperscript{11} as well as articles reporting that percutaneous technique is superior.\textsuperscript{12} Also some authors indicated that there was no difference between the two techniques.\textsuperscript{13}

Arslan et al. have described the biological open technique by protecting the paratenone and tendon blood flow, and reported that they achieve near-perfect results in terms of AOFAS, range of motion and proprioception with this method.\textsuperscript{14} In the presented series the same technique described by Arslan et al. was used, however no correlation between the long term functional scores and elastographic results was detected.

Although we obtained good functional results similar to the authors, a significant difference was observed in favor of the intact tendon in elastographic measurements. This might be due to the fibrosis occurring while the tendon heals and the increased amount of collagen type 3. This is also supported with the difference between the AP diameter of the repaired tendon and the intact tendon.

As we know the tendon elasticity varies with age but this will not affect the results of the presented series. Because we had a relatively young patient population and the comparison was made with the patients’ own intact tendons. This was also confirmed by that the age did not have a correlation with other parameters in our study.

Compression elastography depends on the depth of the affected tissue, the probe position, and the person who performed it.\textsuperscript{14} In our study, after measuring the neutral dorsiflexion angle while the patient was lying in the prone position, measurements were made perpendicular to the tendon with the probe holder by the same radiologist. Thus, differences that may occur depending on the practitioner have been removed.

Karatekin et al. conducted a study including patients with at least 4 years of follow-up examining two different suture methods, and stated that regardless of the suture technique, all operated Achilles tendons showed lower elasticity compared to the intact side.\textsuperscript{15}

Zhang et al. reported that different phases of tendon healing correlated with elastography and this was correlated with the AOFAS score.\textsuperscript{16} Yamamoto et al. in their experimental study on rabbit Achilles tendon, showed a marked increase in strain ratio and found that the tendon was more stiff. In addition, they found a correlation between the histological and mechanical properties of the tendon that healed with strain ratio.\textsuperscript{17} In our study, while the functional results of the patients who were followed up for a long period were quite satisfactory, significant differences were observed between the elastographic results. It was observed that high or low difference between elastography results did not correlate with tendon’s functional results. Even similar functional results were detected in the patient with 26-times strain ratio variation and the case with 2.5-times strain ratio variation.

Some authors argue that the elastic properties of the tendon correlate with the clinical situation and find this method to be useful in the follow-up of the treatment.\textsuperscript{10,17} In this study no correlation was
detected between strain ratio and AOFAS score. For this reason we don’t agree that elastography is efficient in determining the effectiveness of the treatment in patients who have finally completed recovery and who have a long-term follow-up. Although the blood-supply of the tissue was preserved as much as possible by protecting the paratenone, we would like to point out that the repaired tendon tissue was found to be significantly weak when compared with the intact tendon in terms of elasticity. The strengths of this study are that the measurements were made by a single radiologist, all patients were operated by a single surgeon with the same suture material and the same surgical technique, the same rehabilitation method was applied and there is a long period of follow-up. The weaknesses include the absence of a control group and a relatively low number of patients.

CONCLUSION

Even after a long follow-up period of approximately 5 years, there was no correlation between the functional results of the tendon and elastography. In this context, we think that elastography is not a useful technique to evaluate functional results on long-term tendon healing.

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