Achilles tendon and calf tissue dynamics 6, 18 and 32 months after surgical treatment of Achilles tendon rupture - A methodology and case description

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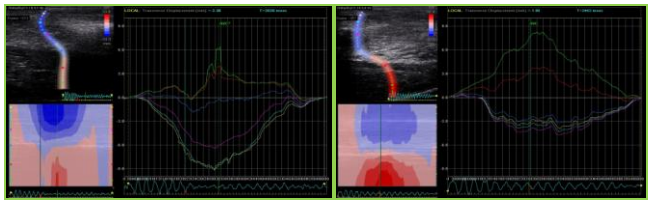
INTRODUCTION

Achilles tendon rupture is a common injury as a consequence of sports- and exercise accidents. The period of rehabilitation is long (6 to 12 months), and only approximately 54% of patients will regain the same level of performance after either surgical or conservative treatment (Möller et al 2001[1]). Thus, there is a need for developing and evaluating new interventions- and rehabilitation programs. New ultrasound techniques, partly based on pattern recognition, can provide information about regional (segmental) tissue deformation and deformation rates.

METHODS

A 30 year old male, active runner, who had undergone surgical treatment with a primary suture, has been followed up at 6, 18 and 32 months after surgery. At each occasion ultrasound registrations (GE, Vivid7, Horten Norway, 12 MHz linear probe) were conducted on the Achilles tendon while performing a 30º loaded functional heel raise. The probe was placed longitudinally over the tendon so that the posterior process of the tibia was visible distally. In the evaluation, a speckle tracking algorithm (EchoPac, Horten, Norway) was applied post process on the grey scale images. to provide information about regional displacement in the tendon. The speckle tracking algorithm relies on scattered echoes (acoustic markers Korinek et al[2]) arising from inhomogeneities in the tissues. When echoes interact a complex interference pattern is generated and different parts of a tissue will have relatively stable and unique speckle patterns over time. The software makes use of a visible Region Of Interest (ROI), divided into 3-6 coloured measurement segments, kernels. Shape, orientation, location and number of kernels are user-defined. In this study, the ROI is inserted perpendicular to the length of the tendon (see upper left part of the images below). The length of the ROI starts in the dorsal tendon and ends just dorsal to the tibia.



The left image shows the healthy side and the right image the injured. The top left part of the images shows the grey scale loop with the tagging ROI. Red indicates kernels moving to the right and blue to the left. The shape of the upper part of the ROI (the tendon area) is smooth in left registration and stiff in right. The right part of each image contains the calculated result of the kernels during the ROM. The injured tendon show a tight distribution between the kernels located in the callus (tendon) while the healthy tendon is dynamic.

The kernels (shown as colored points in the image) are manually placed in a way that three portions of the Achilles tendon (the dorsal, central and ventral) are captured. Further, activities in M Soleus, M Fl Hallucis longus, and M Tibialis posterior are captured with the remaining kernels. The ROI is placed in the first frame and the algorithm will attempt to find the kernels of the same size and pattern frame by frame. The relative displacement of the kernels is calculated frame by frame. In this way the kernels describe both intra-tendinous dynamics and inter-muscular interplay. The test person's healthy side is used as a reference.

RESULTS AND DISCUSSION

The callus in the injured side decreased in volume between the three measurements. However, the tissue dynamic within the callus were highly limited compared to the healthy side, where a smooth dynamic deformation was seen in the tendon (see image). The intra-tendinous relationship could be described as a shear strain relationship between the three portions of the tendon. This pattern was characterized by larger strains in the ventral part than the dorsal part of the tendon. This strain differentiation pattern was not seen in the injured side at any time point during the follow up period. On the contrary, the three portions moved in parallel, showing hardly any internal dynamic at all (see table). There was also a tendency that the inter-muscular relationship between M Soleus and M fl Hallucis was altered compared to the healthy side during the heel raise.

Months after surgery	**6 months**	**18 months**	**32 months**
Callus diameter (mm)	17,0	13,1	13,7
Difference in dorsal-ventral displacement healthy side	1,7	1,8	1,2
Difference in dorsal-ventral displacement rupture side	0,05	0,03	0,02

CONCLUSIONS

The ultrasound based speckle tracking method was able to visualize, localize, differentiate and quantify the tissue dynamics in the healthy and injured tendon and muscles of the calf. It seems that an altered 'stiffer' tendon and callus may affect the calf muscle function at least 32 months after injury.

REFERENCES

1. Möller M, et al. Acute rupture of tendon Achillis. A prospective randomised study of comparison between surgical and non-surgical treatment.
2. Korinek, J, et al. Two-Dimensional Strain – A Doppler Independent Ultrasound Method for Quantification of Regional Deformation: Validation In Vitro and In Vivo. J of Am Soc Echocard, 18;12: 1247-53.