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Magnetic resonance imaging findings of chronic plantar fasciitis before and after extracorporeal shock wave therapy

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ABSTRACT

Introduction: The objective of this study is to examine the relationships between treatment outcome and changes in magnetic resonance (MR) imaging findings after extracorporeal shock wave therapy (ESWT) for chronic plantar fasciitis.

Methods: The subjects were 23 feet of 23 patients of refractory plantar fasciitis. The mean age was 53.7 years. The thickness of the plantar fascia (PF) and findings of a high-signal intensity area (HSIA) inside the PF, edema around the PF, and bone marrow edema (BME) of the calcaneus were investigated on MR images. The Japanese Society for Surgery of the Foot (JSSF) ankle-hindfoot scale and a visual analogue scale (VAS) were used. Correlations between an improvement in symptoms and one in the MRI findings were analyzed.

Results: The mean thickness of the PF was 4.4 ± 1.6 mm before ESWT and 4.6 ± 1.8 mm six months after ESWT. After ESWT, there was a decrease in the numbers of feet showing HSIA inside the PF from 15 to 6, in edema around the PF from 16 to 2, and in BME of the calcaneus from 11 to 4. Clinical outcomes improved with ESWT from 70.3 ± 5.5 to 88.6 ± 9.1 points (JSSF), 74.1 ± 25.3 to 28.5 ± 24.4 points (VAS), respectively. Improvements in symptoms according to the JSSF and VAS scores and improvement in edema around the PF on MR images showed a significant correlation.

Conclusions: Edema around the PF improved significantly in association with an improvement in symptoms after ESWT.

1. Introduction

Plantar fasciitis is a typical disease that causes pain in the plantar calcaneus. Obesity [1], age [2], pes planus [3], pes cavus [4], tension of the Achilles tendon [5], and more have been said to be related to its etiology. Histopathologically, findings such as micro tearing of the plantar fascia (PF), degeneration and necrosis of the collagen fibers, angiofibroblastic hyperplasia, and calcification have reportedly been observed [6].

Plantar fasciitis is mainly treated conservatively. Stretching, bracing, drug therapy, and physical therapy have all been reported [7–12], but many cases have proven refractory. For refractory cases, fasciotomy has been performed. With fasciotomy, it has been reported that 80–85% of cases improve, but it has disadvantages, including postoperative scarring, nerve damage, a reduction of the longitudinal arch of the foot, and a long recovery period [13–15]. For about 20 years, extracorporeal shock wave therapy (ESWT) has been used for refractory plantar fasciitis. ESWT has the significant advantages of being less invasive and requiring a shorter recovery time than fasciotomy, and in many reports it has been stated as having a favorable outcome [16–20]. The mechanism of action of ESWT has been reported to be pain relief through stimulation of soft tissue healing by removal of inflammatory debris and promotion of neovascularization, reduction of calcification, and inhibition of pain receptors or denervation [21,22], but how ESWT exerts its pain-relieving effects on plantar fasciitis is unknown.

Various studies have been reported for imaging of plantar fasciitis [3,23]. Magnetic resonance images (MR images) in particular offers superior visualization of soft tissue and is optimal for assessing the condition of the tendons and ligaments [24]. MR images of plantar fasciitis have also been reported in the past, but the resulting findings are regarded as non-specific, and MR images were often performed for the purpose of differential diagnosis from another disease [25].

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However, thickening of the PF, T2 high signal intensity area in the fascia, edema around the PF, BME of the calcaneus, and more have been noted on MR images of plantar fasciitis [26–30] and it has been reported that associations with symptoms were observed. There is no prior report on the imaging findings of plantar fasciitis over time after ESWT, and the changes after ESWT are unknown. We therefore thought that and understanding of the changes in MRI findings from before to after ESWT may be useful for elucidating the mechanism of action of ESWT. The purpose of this study was to compare treatment outcomes and changes in MRI findings after ESWT for refractory plantar fasciitis, and examine the origins of the pain relief effects of ESWT.

2. Materials and methods

2.1. Patient population and treatment

A total of 23 feet in 23 patients (10 males, 13 females) of refractory plantar fasciitis that underwent ESWT in 2013 were studied. The patients' mean age was 55.3 years (range 16–81 years). Mean disease duration was 26.9 months (4–300 months), and the follow-up period was six months in all cases. The study was approved by the local university ethical committee. Written informed consent was obtained from all participants.

In terms of treatment strategy, conservative treatment, such as stretching of the PF and Achilles tendon, oral NSAIDs, bracing, and steroid injections, was performed first. Then, ESWT was performed if improvement was not seen after at least three months.

The extracorporeal shock wave pain relief device used was the Epos Ultra (Dornier MedTech, Tokyo, Japan). Treatments were provided by a physician, without anesthesia. Aiming at the PF attachment under ultrasonic guidance from the sole, irradiation with a total energy of 1300 mJ/mm^2 (about 3800 rounds, 1 shock = 0.03–0.36 mJ/mm^2) from the medial calcaneus [11,20,31] was performed. A second treatment was performed if symptoms persisted at three months after the first treatment.

2.2. Evaluation with MR imaging

All cases underwent MRI (Magnetom symphony 1.5-T, Siemens, Tokyo, Japan) of both feet before treatment, in a neutral position of ankle-plantar dorsiflexion. Then, six months after treatment, only the affected feet underwent MRI. On MR images, four items were examined: thickness of the PF, HSIA inside the PF, edema around the PF, and BME of the calcaneus. For the thickness of the PF, the maximum diameter of the PF at the calcaneal attachment was measured on T1-weighted coronal images [32] (Fig. 1a). STIR sagittal images and coronal images were used to investigate the other three items [26,30] (Fig. 1b–d). MRI findings were evaluated by specialists (MM and KI) in ankle surgery who are familiar with MR images.

2.3. Assessment of clinical outcomes

The Japanese Society for Surgery of the Foot ankle-hindfoot scale (JSSF score) [33,34] and a visual analogue scale (VAS) were used as clinical assessments, and they were evaluated before and six months after ESWT. The VAS was assessed by the patients themselves, with 100 mm being the most pain they had ever experienced and 0 mm being no pain [35]. Cases who scored 80 points or higher on the JSSF at six months after implementation were considered the JSSF improvement group [34], and cases whose VAS improved to 50% or lower from before implementation were considered the VAS improvement group [18].

2.4. Statistical analysis

The paired t-test was used to compare JSSF scores and VAS scores before and after ESWT. Spearman's rank correlation coefficient was used for the analysis of correlations in symptom improvement and improvement in the four MRI findings. A significant difference was set as $p < 0.05$.

3. Results

3.1. Clinical outcomes before and after ESWT

The mean VAS was 74.1 ± 25.3 mm before ESWT and 28.5 ± 24.4 mm six months after ESWT, representing a significant improvement ($p < 0.05$). The mean JSSF score was 70.3 ± 0.5 points before ESWT and 88.6 ± 9.1 points sixth months after ESWT, representing a significant improvement ($p < 0.05$). A significant difference between men and women was not observed on the VAS (Table 1, before ESWT: $p = 0.98$, after ESWT: $p = 0.24$) or the JSSF score (Table 1, before ESWT: $p = 0.11$, after ESWT: $p = 0.41$). Symptom improvement on the VAS occurred for 19 feet, and symptom improvement on the JSSF score occurred for 16 feet.

3.2. MRI findings

On MRI findings before ESWT, the mean thickness of the PF was 3.1 ± 1.0 mm for healthy feet and 4.4 ± 1.6 mm for affected feet, with a significant difference between the two groups ($p < 0.01$). HSIA inside the PF was observed in 0 healthy feet and 15 affected feet. Edema around the PF was observed in 0 healthy feet and 16 affected feet. BME of the calcaneus was observed in 0 healthy feet and 11 affected feet (Table 2). On MR images of affected feet after ESWT, thickness of the PF was 4.6 ± 1.0 mm, with no significant difference compared to before ESWT. HSIA inside the PF, edema around the PF, and BME of the calcaneus were observed in six feet, two feet, and four feet, respectively, after ESWT.

3.3. Correlation analysis

In the analysis of correlations between improvement in clinical assessment and one on MRI findings, a significant correlation with an improvement in edema around the PF was observed for both the VAS and JSSF score (Table 3, VAS: $R = 0.63$, $p < 0.01$, JSSF score: $R = 0.57$, $p < 0.01$).

4. Discussion

Four MRI findings have been reported in plantar fasciitis: thickening of the PF, edema around the PF, HSIA inside the PF, and BME of the calcaneus [26,27,29,32]. Thickening of the PF has been reported at a mean of 7.56 mm (10 feet) by Berkowitz et al. [26] and a mean of 6.69 mm (18 feet) by Zhu et al. [30]. The present study found a mean of 4.44 mm (23 feet), which is less than past reports, but the mean thickness was 3.1 mm in healthy feet, which means that the PF was significantly thickened in the affected feet. Conceivable reasons for why there was a difference from other past reports are the fact that in the present cases, the thickness had significant variance, between 2.0 and 8.1 mm, and there was also the possibility of racial differences. Regarding the other MRI findings, Grasel et al. [32] reported that of 56 feet, 76% had edema around the PF, 52% had HSIA inside the PF, and 56% had BME of the calcaneus. Maier et al. [28] reported that of 48 feet, 77% had edema around the PF, 87% had HSIA inside the PF, and 79% had BME of the calcaneus. The present study also found frequencies that were similar to previously reported cases, with 69.6% (16 feet) having edema around the PF, 65.2% (15 feet) having HSIA inside the PF, and 47.8% (11 feet) having BME of the calcaneus. When the healthy feet were also examined in the present study, the result was that none of these MRI findings were found in the healthy feet. It thus follows that these MRI findings are all abnormal findings that are

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