ABSTRACT

Background and Purpose: Musculoskeletal ultrasound imaging (MSK US) is an emerging diagnostic tool in physical therapy, which allows for dynamic visualization of tissues in real time. Plantar fasciitis is a common condition causing heel and arch pain and has been related with degenerative changes in the plantar fascia resulting in tissue thickening. Instrument Assisted Soft Tissue Mobilization (IASTM) is an intervention that allows clinicians deep penetration to treat tissues. The mechanical forces caused by IASTM might cause localized tissue trauma leading to stimulation of the body’s natural inflammation and healing processes. The purpose of this case report is to demonstrate the use of ultrasound imaging to guide the decision-making process and to discern the optimal location for the application of IASTM.

Case description: The subject was a 46-year-old female yoga practitioner and runner, who presented with right foot pain. The clinical impression was formulated based on the combination of traditional physical therapy examination procedures and MSK US imaging findings of the plantar fascia demonstrating thickness and tendinosis like changes within the plantar fascia 3 cm distally from the calcaneus.

Outcomes: The subject was seen for eight treatment sessions over four weeks, at which time the goals of normal ankle dorsiflexion, no pain with palpation of the plantar fascia, negative windlass test, and no reported pain during gait were achieved.

Discussion: This case report illustrates the use of MSK US imaging as a method to objectively assess tissue quality and guide decision-making when managing patients with plantar fascia related pain. MSK US was used to determine the optimal location for the application of IASTM during the conservative management of a runner with plantar fasciitis.

Level of evidence: Therapy, Level 5

Key words: Instrument Assisted Soft Tissue Mobilization, Movement system, Musculoskeletal Ultrasound imaging, Plantar fasciitis
BACKGROUND AND PURPOSE

Foot and ankle injuries occur commonly in sports related activities, such as running, resulting in pathologies including Achilles tendinopathy, plantar fasciitis, and cortical stress fractures. Diagnostic imaging is often used to diagnose conditions, however the value of imaging as it relates to the treatment of musculoskeletal system conditions has been controversial due to the fact that anatomical changes not necessarily correlate with pain and dysfunction. Clinical decision-making is dependent on the accuracy and reliability of clinical tests and should not be based on imaging alone. However, when correlated with patient history and physical findings the likelihood of proper imaging related decisions and interventions increases. Musculoskeletal ultrasound imaging (MSK US) is an emerging diagnostic tool in medicine and physical therapy, which allows for dynamic visualization of tissues in real time with devices that are often portable. Recent advances in ultrasound technology and the development of high-resolution ultrasound transducers has resulted in improved visualization of soft tissues and bony structures. MSK US can be used to evaluate tissue properties such as the orientation and volume of fibers, as well as the presence of inflammatory processes, therefore can be a valuable diagnostic and prognostic tool for the physical therapist. Based on these advances the use of MSK US in the management of athletes has been growing. MSK US is a safe noninvasive imaging technique. It is safe for all patients, including those with cardiac pacemakers and metal implants, without any contraindications. MSK US imaging can easily be repeated and is therefore an effective tool to monitor tissue changes over time. Scheel et al demonstrated that inter-tester reliability, sensitivity, and specificity of MSK US imaging performed by rheumatologists in comparison with MRI ranged from moderate to good. Based on the current evidence MSK US appears to be a valid and reliable tool to evaluate the musculoskeletal system and should be considered as a possible diagnostic tool. Additionally, MSK US imaging is within the scope of practice of the physical therapist and can easily be integrated into clinical practice now as US units are becoming more affordable.

Plantar fasciitis is a common condition causing medial heel and arch pain. Plantar fasciitis is the most common foot condition seen in clinical practice, which affects about two million Americans annually. There is a life span incidence of plantar fasciitis of about 10%. It has been reported that the prevalence of plantar fasciitis is between 11 to 15% of all foot symptoms, with a higher occurrence between the ages of 40 and 60. Risk factors for the development of plantar fasciitis including obesity, prolonged standing, poor ankle biomechanics, a decreased medial arch height, leg length inequity, heel spurs, and sports activities such as running. Plantar fasciitis accounts for about 10% of all running related injuries. With conservative management it has been reported that 80% of the cases will have symptom resolution within 12 months.

It is believed that plantar fasciitis is the result of prolonged loading resulting in adaptive changes in the fascia. It has been related to degenerative changes in the plantar fascia resulting in tissue thickening, which could include proliferation of fibroblasts and a perpetuating inflammatory cycle. The localized healing responses results in the production of new connective tissue, which is laid down in a disorganized fashion and will cause the formation of adhesions and thickening of the plantar fascia. Toomey previously demonstrated that a decrease in plantar fascia thickness was positively related with a reduction of pain in subjects with plantar fasciitis.

The 2014 revised clinical guidelines for heel pain and plantar fasciitis recommend conservative management of plantar fasciitis to include joint and soft tissue manipulation, triceps surae and plantar fascia muscle elongation, the short-term use of taping, foot orthosis to support the medial arch, short term use of iontophoresis, low level laser, and education and counseling on the use of exercise to achieve a better body mass index. Additionally, It has been reported that the use of instrument assisted soft tissue mobilization (IASTM) is beneficial. IASTM is a modality that allows clinicians to achieve a localized and deep penetration of tissues, while reducing stress placed on the hands and fingers of clinicians. Although the exact effects of IASTM remain elusive, mechanical forces caused by the IASTM might result in localized tissue trauma leading to stimulation of the body’s natural inflammation and healing processes. The proposed benefits of IASTM are at
the molecular and cellular level. Loghmani and Warden examined the response to IASTM on the knee ligaments of rats and found that changes in the tissues appear to be the result of stimulation of the fibroblasts located within the myofascial tissue layers. This gives the tissue the opportunity to restart the fibroblastic healing and remodeling process so that it has an opportunity to restore appropriately.

It has also been proposed that IASTM may decrease pain through the stimulation of mechanoreceptors within the tissues resulting in the inhibition of nociceptor activity. This decrease in localized pain may contribute to increased range of motion, reduction of tissue tension, increase in tissue extensibility and producing normalization of neuromuscular movement patterns. Typically, IASTM is used in combination with other interventions. Looney et al reported that IASTM followed by two repetitions of 30 seconds static stretching and 20 minutes of icing resulted in clinically meaning changes in active range of motion. The exact dosing of IASTM is not clear, however, recommended treatment time ranges from a few minutes up to 20 minutes.

Therefore, the purpose of this case report is to demonstrate the use of ultrasound imaging to guide the decision-making process and to discern the optimal location for the application of IASTM.

CASE DESCRIPTION: SUBJECT HISTORY AND SYSTEMS REVIEW

The subject of this case report was an otherwise healthy 46-year-old mesomorphic female yoga practitioner and recreational runner, who was referred to physical therapy by a local podiatrist. She had developed pain in the arch of the right foot six months ago after a three-mile run. After three weeks of unsuccessful self-management, which included icing and stretching, she sought medical care. She underwent a comprehensive evaluation and a plain film radiograph displayed a heel spur at the plantar aspect of the calcaneus, but no evidence of OA or cortical fracture. She was diagnosed with plantar fasciitis. Her podiatrist recommended cortisone injections and placed the foot in a rigid brace to immobilize the tissue. In total, she received two cortisone injections and was immobilized for six weeks. Following this she was transitioned to a soft brace, night splint, and was advised to increase her functional activities gradually and initiate self-stretching. She was not able to manage her condition independently and she remained functionally limited. She was not able to return to her normal running activities or participate in her normal yoga activities, for that reason she was referred to physical therapy.

She reported that her pain was localized on the plantar medial aspect of the heel and medial arch. This pain was provoked with standing and walking. Especially, the first couple of steps were painful after not being on the feet for a while. She reported that taking her weight off the foot decreased her pain and after several minutes the pain typically was completely gone. At the time of the evaluation she reported heel pain, but her medial arch pain was worse. Her pain was typically contained to the foot region although occasionally she did experience pain along the medial shin region. She reported that after being on her feet for a while she developed pain in the lateral right hip region. The screen for yellow and red flags was negative and she denied the presence of numbness in lower extremity.

At the time of physical therapy evaluation, she described both her heel and arch pain using the Numeric Pain Rating Scale (NPRS). The NPRS is a frequently used tool to quantify subjective pain and it has been previously recommended for the self-report of pain. The validity and reliability of the NPRS has been previously reported for patients with acute and chronic pain. She reported her pain at the heel at 3/10 and in the medial arch at 6/10. The Lower Extremity Functional Scale (LEFS) was used as a patient reported outcome measure. The Lower Extremity Functional Scale (LEFS) can be used to evaluate the functional impairment of a patient with a disorder of one or both lower extremities. It can be used to monitor the patient over time and to evaluate the effectiveness of an intervention. The LEFS is a 20-item self-reported measure with each item a possible score 0-4, resulting in a total maximum score of 80. Higher scores on the LEFS indicate greater disability levels. At the time of examination her score was 39/80, which indicates a moderate level of disability. The validity, reliability, and responsiveness of the LEFS has been previously shown in patients with plantar fasciitis. The
minimal clinically significant difference of the LEFS is a 9-point change.27

Clinical Impression #1
The subject experienced a sudden onset of heel pain after a three-mile run. Her pain was typically worse with weightbearing and did result in pain of the hip region. Differential diagnosis consisted of calcaneal contusion, calcaneal stress fracture, inflammatory arthropathy of the mid tarsal or subtalar joints, and plantar fasciitis or plantar fascia rupture. Due to the fact that her plain radiographs were negative, and had been immobilized for six weeks, the likelihood of underlying cortical fractures seemed low. The fact that weightbearing/loading activities continued to provoke her symptoms in the heel and medial arch led the authors to the discern that the plantar fascia was the underlying cause of the subject's symptoms. She reported an unremarkable medical history with a negative general health screen for the presence of red or yellow flags; therefore, further examination of this subject was appropriate. Examination included ruling out cortical bone as the cause of symptoms with the use of MSK US and joint mobility assessment followed by soft tissue assessment to further identify related tissues contributing to the subject's presentation.

EXAMINATION

Initial observation
Upon arrival to the examination (Table 1), the subject ambulated with a shortened stance phase and a positive Trendelenburg on the right. This gait pattern could be indicative of gluteus medius weakness and might indicate the presence of a regional interdependent multifactorial issue in this case.29-32 However, it was considered that six weeks of boot usage could have resulted in talocural joint limitations and an altered neuromuscular firing patterns.33,34 She reported pain in the right foot during the first couple of steps. She appeared comfortable when seated during her intake interview. Visual inspection in standing revealed a forward head posture, an increased thoracic kyphosis, increased lumbar lordosis, minimal knee valgus on the right, pronation of the calcaneus R>L, pes planus valgus R>L, and minimal hallux valgus on the right. Poor postural positioning can be attributed to a variety of musculoskeletal dysfunctions, which include ankle/foot pain, knee pain, hip pain, and lower back pain.35-37

Joint motion assessment
Active range of motion of the hip, knee, ankle and foot (AROM) was assessed in supine using a goniometer. It has been previously suggested that AROM assessment using a goniometer is valuable when examining patients with ankle/foot dysfunction in non-weightbearing.38,39 She displayed decreased dorsiflexion of the right ankle both with the knee in extension and flexion. This could indicate either a capsular restriction or a soleus tightness contributing to her motion deficit. Arthrokinematic assessment of the talocural joint displayed a decreased posterior/inferior glide of talus. There was an increased medial glide of the calcaneus in the subtalar joint, which correlates to the pronation of the calcaneus seen in standing. She also displayed an increased plantar glide of the navicular in the transverse tarsal joint line which supports the observation of a decreased medial arch in standing. The fact that she displayed hypermobility of the subtalar and midtarsal joint ruled out inflammatory arthropathy as the underlying cause of her symptoms.

Neurological assessment
She did not display any signs of neurogenic sensitivity in the lower extremity. There was a negative straight leg raise, and a negative Tinel test for the tarsal tunnel. She displayed normal lower extremity muscle stretch reflexes and normal myotomal strength in the lower quadrant. Palpation for position in standing revealed positive navicular drop compared to the left side and this likely contributed to her pes planus valgus and altered gait pattern.40

Palpation and tissue specific assessment
Structural palpation revealed a painful plantar aspect of the calcaneus. There was hypertonicity of the plantar fascia R>L and there was pain upon palpation of the plantar fascia in the region of the navicular. To further examine the structures of the foot and the quality and integrity of the plantar fascia MSK US imaging (GE Healthcare, Chicago Il, Venue 40) was used. The scanning protocol was based on the fact that the reliability of using MSK to evaluate plantar fascia thickness was previously reported as high.
with good intertester agreement when using the longitudinal scanning method. Figure 1 displays the position of the probe when assessing the plantar fascia using the longitudinal scanning method. Figure 2 displays the MSK US image of a normal foot. When evaluating an MSK image the clinician will use the variance in tissue density displayed in a variance of the gray scale to identify normal and abnormal tissues. Denser tissues will present as hyper-echoic (white) signals and tissues with lower density, such as fluid, as hypo-echoic (black). The calcaneus is identified as the highly reflective hyper-echoic curved line with dark shadowing underneath as no sound waves pass the cortical bone. The planar fascia presents with a hyper-echoic fibrillar pattern in which the thickness is the generally same throughout the structure. Figure 3 displays the image of the right plantar fascia of the subject. Imaging demonstrated intact cortical calcaneal bone without the presence of any signs of fluid around the cortical structures, thereby ruling out cortical bone as the cause of symptoms. MSK imaging did identify that there was thickening of the plantar fascia 3 cm distal from the calcaneal origination. Additionally, this region demonstrated a tendinosis type presentation with several areas of disruption (hypo-echoic areas.

Table 1. Summary of relevant examination and re-examination findings.

<table>
<thead>
<tr>
<th>Visit</th>
<th>1 (Initial visit)</th>
<th>2</th>
<th>3</th>
<th>4 (Reexamination)</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8 (Reexamination)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPRS heel</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>NPRS arch</td>
<td>6</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>LEFS</td>
<td>39</td>
<td>24</td>
<td></td>
<td>11</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ankle DF-knee straight (degrees)</td>
<td>5 (17 on the left)</td>
<td>11</td>
<td>15</td>
<td>16</td>
<td>16</td>
<td>15</td>
<td>15</td>
<td>18</td>
</tr>
<tr>
<td>Ankle DF knee flexed (degrees)</td>
<td>8 (22 on the left)</td>
<td>12</td>
<td>17</td>
<td>17</td>
<td>18</td>
<td>18</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>MTP Dorsiflexion with ankle plantar flexion</td>
<td>65</td>
<td>65</td>
<td>65</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knee flexion/ Extension</td>
<td>Normal compared to left</td>
<td>Normal compared to left</td>
<td>Normal compared to left</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hip flexion/ internal rotation/ extension</td>
<td>Normal compared to left</td>
<td>Normal compared to left</td>
<td>Normal compared to left</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arthokinematic assessment</td>
<td>decreased posterior glide talus</td>
<td>Increased medial glide calcaneus</td>
<td>Increased plantar glide navicular</td>
<td>Normal posterior glide talus</td>
<td>Increased medial glide calcaneus</td>
<td>Increased plantar glide navicular</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neurovascular testing</td>
<td>(-) Tinel at tarsal tunnel</td>
<td>(-) SLR</td>
<td>(-) pulse palpation</td>
<td>(-) Tinel at tarsal tunnel</td>
<td>(-) SLR</td>
<td>(-) pulse palpation</td>
<td>(-)</td>
<td></td>
</tr>
<tr>
<td>Windlass test</td>
<td>(+)</td>
<td>(+)</td>
<td>(-)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MSK US</td>
<td>(+) thickening plantar fascia 3 cm distally of insertion</td>
<td>(+) for tendinosis like changes in the fascia structure</td>
<td></td>
<td>(+) but decreased thickening plantar fascia 3 cm distally of insertion</td>
<td>(+) for tendinosis like changes in the fascia structure</td>
<td></td>
<td>(+) for tendinosis like changes in the fascia structure</td>
<td></td>
</tr>
<tr>
<td>Strength (MMT)</td>
<td>R Triceps surae complex graded 4/5</td>
<td>R Tibialis posterior 3+/5</td>
<td>R Gluteus medius/minimus 4-/5</td>
<td>Flexor digitorum 4/5</td>
<td>R Triceps surae complex 4+/5</td>
<td>R Tibialis posterior 4/5</td>
<td>R Gluteus medius/minimus 4/5</td>
<td>Flexor digitorum 5-/5</td>
</tr>
</tbody>
</table>
within the hyper-echoic fibrillar pattern) appearance on imaging of collagenous fibers within the fascia.\(^7\) This would confirm the hypothesis that there is a chronic irritation of the planta fascia present in this case.

**Muscle strength/length assessment**

Manual muscle testing revealed marked weakness of the tibialis posterior at 3+/5, weakness of the triceps surae at 4/5, and weakness of the toe flexors at 4/5. Muscle length testing demonstrated muscle shortening of the triceps surae complex on the right and she displayed a positive windlass test on the right.\(^43\) De Garceau et al\(^44\) report that the windlass test has a 100 % specificity and the inter-rated reliability had an ICC of .96, therefore this would confirm the presence of plantar fasciitis in this case.

Based on the regional interdependence model the knee and hip joints were examined for active and passive range of motion. No significant differences were present between the right and left side. She did display a positive valgus stress test of the knee in 0 and 30 degrees of flexion (graded 1+), which seemed to correlate to the valgus knee during stance phase. Manual muscle testing revealed weakness of the right hip abductor group at 4/5 without provocation of any pain. Muscle length testing revealed some hamstring muscle tightness using the 90/90 test with tightness reported at 35 degrees of knee flexion on the right and 15 degrees on the left.

**Clinical Impression #2**

The clinical impression in this case was based on the combination of traditional physical therapy examination procedures and the dynamic MSK US

![Figure 1](image1.png)

*Figure 1. Position of the MSK US probe when assessing the plantar fascia.*

![Figure 2](image2.png)

*Figure 2. Normal MSK US images of a plantar fascia (not actual patient). (a) Yellow arch on the image left is the hyperechoic cortical bone. (b) In the right image the yellow lines outline a normal plantar fascia with equal thickness at three measurement points.*
Interventions and outcomes
Following the examination, the initial treatment focused on normalizing ankle dorsiflexion, improving talocural joint mobility, and decreasing the tightness and hypersensitivity of the plantar fascia. Therefore, treatment included manipulation techniques targeting the talocural joint (Table 2). Both the distraction manipulation and manipulation to improve dorsal glide of the talus were utilized. Ankle dorsiflexion improved from 5 to 11 degrees. Muscle stretching of the triceps surae was performed using a contract-hold-relax-stretch technique with a stretch hold time of 30 seconds and this was repeated 3 times.\(^4\) The stretch intensity was moderate which is considered beneficial and safe.\(^4\) To address the tone of the planar fascia an IASTM approach was utilized using the EDGEility tool (https://www.edgemobilitysystem.com/, Buffalo, NY). The MSK US imaging identified the exact location of the plantar fascia irritation and at this location a five-minute application of short stroking of the fascia was utilized. Initially the subject reported significant sensitivity using the tool however within 60 seconds this became pain free. After the initial manual therapy interventions, her pain upon standing in the arch had decreased from 6/10 to 3/10. This supported the thought that manual therapy techniques would be beneficial in this case. Based on her foot position in standing and the clinical practice guidelines she was recommended to obtain prefabricated arch supports that would position her calcaneus in less pronation.\(^1\) To maximize the carryover of manual therapy interventions the subject was instructed in an augmented exercise program, which included stretching of both the triceps surae and plantar fascia in standing. She was instructed to perform her stretching exercises in such a way that a static stretch was maintained for 30 seconds and repeated three times. Stretching has been shown to be beneficial within the management of plantar fasciitis.\(^1\)

Each treatment session started with assessment of the ankle mobility for dorsiflexion, palpation of the plantar fascia, decreased ankle dorsiflexion with decreased posterior glide of the talus, a negative tarsal tunnel testing, a positive windlass test the findings were consistent with plantar fasciitis.\(^1\) This was further supported by the positive MSK US imaging findings of tissue thickness and tendinosis like changes within the plantar fascia. This led to the hypothesis that this subject could benefit from localized IASTM, joint manipulation, and muscle stretching and strengthening. Successful outcomes were considered as improved NPRS and LEFS scores, normalized AROM of the ankle, normalization of the plantar fascia on MSK imaging, and return to running without symptoms.

**Figure 3.** MSK US images of the plantar fascia upon initial examination. White arrow indicates area of fascia thickening and hypoechoic changes.
reported no pain during gait. MSK US displayed a normal presentation of the plantar fascia of the right foot (Figure 3). She was able to participate in normal yoga activities. She had initiated some running on a treadmill with the prefabricated arch supports in her shoes without symptoms arising. Due to the fact that treatment goals were achieved she was discharged with the instructions to continue to perform muscle stretching, strengthening exercises for the tibialis posterior and hip abductors, and to continue using her arch supports in her shoes. At the one-month follow-up, she continued to be pain free and reported no functional limitations.

**DISCUSSION**

This case report describes how MSK US was used within the management of a 46-year-old otherwise healthy female subject presenting with heel and arch pain limiting her running ability. Based on a cluster of evaluation findings, including AROM, arthrokinematic motion assessment, muscle length

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**Table 2. Interventions and augmented exercise.**

<table>
<thead>
<tr>
<th>Visit</th>
<th>1 (Initial visit)</th>
<th>2</th>
<th>3</th>
<th>4 (Reexamination)</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8 (Reexamination)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Home exercise instruction</strong></td>
<td>Standing with forefoot on towel. Create self-mobilization DF of ankle through knee flexion-2 sets of 10-3x daily</td>
<td>Added self-mobilization of the plantar fascia using foot roller standing heel raise strength exercise for TP and the tibial surae-3 reps to fatigue 2x/day.</td>
<td>Continue with previous home exercise program</td>
<td>Discontinued self-mobilization of the ankle. Added home gait training using a mirror</td>
<td>Continue with previous home exercise program</td>
<td>Continue with previous home exercise program</td>
<td>Continue with previous home exercise program</td>
<td>Continue with strength exercises and stretch program</td>
</tr>
<tr>
<td></td>
<td>Stretch of triceps surae and the plantar fascia 3x 30 seconds-2x daily</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Return to normal yoga participation</td>
</tr>
</tbody>
</table>

| Interventions | Talarcral long axis distraction thrust manipulation | Same as visit 1 added: Standing eccentric strengthening exercises on foam pad for TP and triceps surae till fatigue-3 reps | Same as visit 2 added: Active strengthening and stability training using the foam pad: | Discontinued use of manipulation techniques the rest remained Same as visit 3 Updated HEP | Same as visit 4 | Same as visit 4 | Same as visit 4 | Same as visit 4, Reviewed HEP and DC instruction |
|              | Posterior glide manipulation grade IV 2 min | Instruction in HEP | -1-legged stance -2 heel raise -3 toe raise (3 sets each till fatigue) | One legged stance on wobble board in parallel bar-3x 1 minute | Gait training: stepping activities using mirror feedback for appropriate pelvic control -5 minutes | Instruction in HEP |
|              | IASTM-plantar fascia 5 min with EDGEility tool | | | | | |
|              | Manual stretch plantar fascia and triceps surae 3x 30 seconds. | | | | | |
|              | Instructed in HEP | | | | | | |

IASTM= Instrument Assisted Soft Tissue Manipulation; DF= dorsiflexion; HEP= Home Exercise Program,
and strength assessment, and MSK US imaging findings it appeared that this subject presented with plantar fasciitis. MSK US is a safe noninvasive imaging technique within the scope of physical therapy practice that provides the clinician with an easy, relatively low cost, portable, and dynamic real-time view of human tissues. It can easily be repeated and is therefore an appropriate tool to monitor tissue changes over time. The utilization of MSK US by physical therapists has been steadily growing. It not only aids in the diagnostic process it can also guide (real time) treatment interventions. Initially, MSK US was used by physical therapists to evaluate muscle contractions and as a biofeedback tool during interventions to improve isolated muscle action. Since than it has become useful for diagnosing many conditions such as cortical bone fractures, tendon and muscle morphology, ligament integrity and length, the presence of inflammation including synovitis, bursitis, and nerve related conditions such as carpal tunnel syndrome and Morton neuroma. MSK US has been demonstrated to be a reliable and valid method to assess the musculoskeletal system. Naredo et al demonstrated moderate to good inter-tester reliability when evaluating soft tissue and bony structures with MSK-US. Poltawski et al demonstrated test-retest reliability ranges from .70-.82 when measuring muscle thickness making this a relatively good method to evaluate the thickness of the plantar fascia. One of the disadvantages of MSK US is the fact that the quality of the image is greatly dependent on the experience of the sonographer. The clinician who performed the MSK US in this case report has more than six years of experience using MSK US in clinical practice. It appears that this is a modality even the novice practitioner can use after minimal training. Filippucci et al demonstrated that quality images can be obtained by a novice after a short two hour training by an experienced sonographer followed by 24 non-consecutive hours of active scanning. This concurs with the findings of D’Agostino et al, who suggest that it takes at least 70 examinations to develop competence evaluating the MCP, PIP, and MTP joints. Based on current evidence it can be concluded that even the novice practitioner who undergoes training in MSK US can achieve the acceptable diagnostic accuracy compared to highly experienced sonographers. Based on the anatomical and biomechanical knowledge of the ankle/foot physical trained therapists should be able to produce reliable and repeatable MSK US images.

The exact mechanism underlying the development of plantar fasciitis is not clear. There are several contributing factors that have been identified that could contribute to this syndrome. Such risk factors include age between 40 and 60 years, sudden increase in running distance, change in running surface, prolonged standing, foot pes planus, limitations in ankle dorsiflexion and sudden weight gain or obesity. Age is considered a risk factor, as degenerative changes begin within the plantar fascia. MSK US imaging (Figures 2 and 3) demonstrated that the plantar fascia in this case had a tendinosis type presentation with areas of swelling and disruption of fibers about 3 cm distally of the calcaneal insertion. A characteristic presentation related to degenerative changes in the fascia is the presence of localized hyperemia. This suggests that there could be a neurovascular in-growth which may contribute to foot pain when loading the tissues.

Figure 4. MSK US images of the plantar fascia upon discharge. White arrow indicates normal plantar fascia tissue.
was able to demonstrate abnormal soft tissue vascularity in the plantar fascia with ultrasound imaging. This change in fiber consistency could have led to degradation and weakening of the connective tissue collagen and elastin fibers in the plantar fascia in this case, resulting in impaired shock absorption during running activities.

A second consideration related to the findings of the tissue changes found with the MSK image in this case could be her anatomical presentation. The subject presented with pes planus valgus in both feet with the right greater than the left. In the case of pes planus, one could assume that the medial longitudinal arch is depressed, the subtalar joint is pronated, and the calcaneus assumes a valgus position during weight bearing and more dysfunctional during running activities. This repetitive stress on the plantar fascia to invert the calcaneus during the gait cycle predisposes the tissue to microtearing within the fascia, collagen necrosis, angiofibroblastic hyperplasia and pain.1 McNally and Shetty61 report that a thickening of the plantar fascia greater than 5 mm on MSK US is suggestive of plantar fasciopathy. The MSK US images in this case (Figure 3) clearly identified thickening and degenerative changes supporting the decision that there were structural changes in the fascia.62 This would also explain the fact that her pain likely was not caused by an acute inflammatory processes. Therefore, IASTM would be an appropriate intervention to address these tissue changes within the plantar fascia clinically.

One of the rationales explaining the therapeutic benefit of IASTM is based on the tissue friction effect by the tool believed to increase local blood flow. Additionally, the use of the tool could cause localized tissue trauma resulting in an inflammatory cascade within the tissue.20-22 Figure 5 A depicts an MSK US image prior to the five-minute IASTM intervention and an image of the same tissue directly after the intervention. The Doppler setting was used while creating these images. Doppler MSK US is commonly used to estimate the blood flow through blood vessels with higher flow indicated by more red discoloration within the image. No identifiable circulatory changes can be detected on the post intervention image (Figure 5B) implying that there was none. This observation does not support any circulatory benefits of IASTM to the plantar fascia in this case. Because no cause and effect relationships can be inferred from this case report, future studies should use MSK US to further evaluate the effect of IASTYM on the circulation in the different layers of human tissues in larger sample sizes.

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**Figure 5.** MSK US Doppler images of the plantar fascia before and after IASTM. (a) Prior to intervention. (b) Post 5-minute intervention application.
CONCLUSIONS

MSK US imaging allows the clinician real time visualization of different tissue layers in the human body which can assist the clinician in establishing a differential diagnosis and selecting appropriate treatment interventions. The results of this case report offer preliminary evidence that supports the use of MSK imaging within the evaluation process in the case of a runner with plantar fasciitis. The treatment combination of manual therapy, the use of IASTM directed by MSK US imaging, and stretching, strengthening, gait training, and proper footwear was beneficial. This subject was pain free and returned to full activity and running after eight visits over four weeks. Additional research is necessary to further validate MSK US imaging as a method to objectively assess tissue quality and guide decision-making when managing patients with musculoskeletal injuries.

REFERENCES


