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## Original Research

# Clinical Utility of High-Frequency Musculoskeletal Ultrasonography in Foot and Ankle Pathology: How Ultrasound Imaging Influences Diagnosis and Management

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## ABSTRACT

The use of high-frequency (high-resolution) musculoskeletal ultrasonography is increasing and has shown promising utility in many areas of medicine. The utility of musculoskeletal ultrasonography for foot and ankle complaints has not been widely investigated, however. Although some conditions of the foot and ankle are easily diagnosed by physical examination, others can have nonspecific examination findings, making optimal treatment decisions difficult. We hypothesized that high-resolution musculoskeletal ultrasound scanning of the foot and ankle can affect the diagnosis and/or treatment for patients presenting with foot or ankle complaints. Retrospectively, the cases of 98 patients who had undergone musculoskeletal ultrasound scanning of the foot or ankle were reviewed. The pre-ultrasound clinical diagnosis and treatment were compared with the post-ultrasound diagnosis and treatment. In 64% of the patients, the diagnosis or treatment changed after the ultrasound examination. In 43% of patients, both the diagnosis and the treatment changed after ultrasound scanning. For those patients for whom the diagnosis and treatment were unchanged after the ultrasound examination, the ultrasound findings were concordant with the pre-ultrasound clinical diagnosis for 100% of the patients. These results suggest that in a large proportion of patients, high-resolution musculoskeletal ultrasonography of the foot or ankle can facilitate appropriate diagnosis and management.

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The causes of foot and ankle symptoms that can prompt a patient to seek care from a physician are many. Some of these conditions and their symptoms can be treated with similar conservative measures. Plantar fasciitis, arch pain, and midfoot arthritis, for example, can all be treated with over-the-counter or custom-made foot orthoses, shoe gear modification, stretching, nonsteroidal anti-inflammatory agents, and activity modification (1–3). The conditions included under the umbrella of metatarsalgia, such as neuroma, intermetatarsal bursitis, and joint disease, can have similar presentations but must be distinguished from each other, because the treatments differ (4–8). It can be difficult to distinguish among these conditions (5,6,9). Similar patient presentations and even similar physical examination findings make it

challenging to appropriately treat the patient without knowing the true underlying etiology. Sclerosing alcohol therapy or phenol injections, although appropriate for neuroma (4,8), would not be appropriate for metatarsophalangeal pain or intermetatarsal bursitis, nor would radiofrequency ablation or cryogenic neuroablation (4,6). Because of these divergent treatment strategies for various conditions of the foot and ankle, an accurate diagnosis is imperative.

In conjunction with the clinical examination, radiographs can often illuminate the correct diagnostic path or even provide a definitive diagnosis; however, some patients will require further imaging. Although magnetic resonance imaging (MRI) can provide a wide range of information about soft tissue and bone abnormalities, this modality is costly, and not all patients can undergo an MRI examination because of claustrophobia or the presence of certain implanted devices. Given the high spatial resolution of high-frequency ultrasonography, many abnormalities, especially those in superficial structures, can be detected with greater specificity with ultrasonography than with MRI (10). Because most structures below the knee are relatively superficial and easily

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imaged with modern high-frequency ultrasound equipment, a focused ultrasound examination of the foot or ankle can provide a correct diagnosis. Ultrasonography can also be useful in confirming the clinical diagnosis and supporting the chosen treatment. Patients often tolerate ultrasound examinations better than they do MRI examinations, and the former are also less expensive. Furthermore, using ultrasonography, imaging can be performed directly over the site of the patient's pain or symptoms.

Ultrasonography has been widely used in the evaluation of rheumatologic conditions, for which it has demonstrated utility in influencing the diagnosis and treatment (11,12). For patients presenting to a podiatry practice, however, the utility of musculoskeletal ultrasound examinations have not been widely reported. We propose that high-frequency musculoskeletal ultrasound examination of the foot or ankle can help to confirm a clinical diagnosis or change the clinical diagnosis to ensure appropriate treatment.

### Patients and Methods

The present retrospective study received an institutional review board exemption for quality improvement purposes and a waiver of written informed consent. The study involved an anonymous electronic review of radiology reports, followed by patient identification and subsequent medical record and image review. This was done in compliance with our institutional Health Insurance Portability and Accountability Act policy.

All patients who had undergone musculoskeletal ultrasound examination of the foot or ankle at 1 large, multispecialty radiology practice from January 2012 through November 2013 were included in the present study. Patients who had previously undergone MRI for the relevant complaint were not excluded. The hospital system is a large tertiary-care medical center located in an urban setting. Patients were referred for foot or ankle ultrasound examination by primary care sports medicine physicians and podiatrists. The ultrasound examinations were performed by 10 technologists with specialized training in musculoskeletal ultrasonography, with an average of 4 years' experience. Three of the technologists are registered musculoskeletal sonographers (American Registry for Diagnostic Medical Sonography). All examinations were performed using the Siemens S2000 ultrasound unit (Siemens Medical Solutions, Erlangen, Germany) with high-frequency (14- or 18-MHz) linear probes. The examinations were interpreted with additional hands-on scanning by 1 of 12 musculoskeletal radiologists with an average of 8 years' experience in musculoskeletal ultrasonography. The radiologists' reports for the patients who had undergone ultrasound examinations were identified from the database of our radiology information system (Syngo Workflow; Siemens Medical Solutions). A total of 110 electronic medical records (EpicCare; Epic, Madison, WI) were manually reviewed to identify the clinical diagnosis and treatment course before and after the ultrasound examinations. A total of 98 consecutive patients referred for a musculoskeletal ultrasound examination with no traumatic injury who had complete clinical data in the medical records were included.

The clinical diagnosis of the cases was inflammatory condition in 36, Morton neuroma in 16, traumatic or mechanical condition in 15, a questionable mass (other than neuroma) in 10, a foreign body in 8, a degenerative condition in 7, a neuropathic condition in 4, and an infectious process in 2. The post-ultrasound diagnosis was compared with the pre-ultrasound clinical diagnosis and noted as either unchanged or changed. In addition, the treatment plan after the ultrasound diagnosis was compared with the treatment plan before the ultrasound examination and noted as unchanged or changed.

### Statistical Analysis

The proportion of all consecutive patients for whom the musculoskeletal ultrasound findings influenced the diagnosis or treatment plan was used as a measure of the modality's utility. A 95% Agresti-Coull confidence interval (CI) was calculated for this proportion. To further summarize the utility of musculoskeletal ultrasonography, the numbers of patients for whom both the diagnosis and treatment were changed, only the diagnosis was changed, and neither the diagnosis nor the treatment was changed were calculated. Again, 95% CIs were calculated for these proportions. When neither the diagnosis nor the treatment was changed, the proportion of cases for which the musculoskeletal ultrasound findings confirmed the original diagnosis was calculated. Because this was a retrospective study, a universal reference for diagnosis was not available. However, some patients had subsequently undergone surgery, some had subsequently undergone an MRI examination, and many had clinical follow-up data available after the high-frequency musculoskeletal ultrasound examination, allowing for assessment of the success of the treatment plan.

### Results

A total of 98 consecutive foot and ankle patients were included in the present study (mean age  $51 \pm 14$  years; 59 [60.2%] females). Musculoskeletal ultrasound examination of the foot or ankle affected the diagnosis and/or treatment plan for most of the patients in the study. The diagnosis or treatment was changed for 63 study patients (64%; 95% CI 54% to 73%). For 42 of these patients (43% of all patients; 95% CI 34% to 53%), both the diagnosis and the treatment were altered. For 21 patients (21% of all patients; 95% CI 14% to 31%), only the diagnosis was changed by the ultrasound findings, without a change in the treatment plan. For 35 patients (36% of all patients; 95% CI 27% to 46%), neither the diagnosis nor the treatment plan was altered; for all 35 patients, the ultrasound findings confirmed the initial clinical impression. Of the 98 patients, 7 (7%) subsequently underwent surgery. For these 7 cases, the ultrasound and surgical diagnoses were the same. Of the 98 patients, 18 (18%) underwent MRI either before or after the ultrasound examination. In 12 of these cases, the MRI and ultrasound diagnoses were the same. However, for the remaining 2 patients, MRI did not yield the final diagnosis, but the ultrasound findings did. Of the 98 patients, 64 (65%) improved with the treatment plan based on the ultrasound diagnosis. In 9 of the 98 patients (9%), the initial treatment plan based on the ultrasound findings failed or the patients eventually received a diagnosis different from the ultrasound diagnosis. Of the 98 patients, 18 (19%) had no follow-up data documented after the ultrasound examination ( $\leq 4$  years later). For 71 patients (72%), the ultrasound findings were either confirmed by surgery or the patient's symptoms improved or resolved after the musculoskeletal ultrasound examination.

Four case examples are outlined, illustrating the different ways in which the musculoskeletal ultrasound findings affected the diagnosis and treatment in the present study.

#### Case 1

A 54-year-old female presented with right third intermetatarsal space pain at the metatarsal heads with deep palpation. The clinical diagnosis was a Morton neuroma; however, conservative treatment failed in this patient. Treatment with surgery or radiofrequency ablation was then considered, and an ultrasound examination was performed. The musculoskeletal ultrasound findings revealed a normal plantar nerve (Fig. 1A) in the third intermetatarsal space but also demonstrated mild bursitis (Fig. 1B) at the area of pain. A steroid injection was performed, which relieved the pain. In this case, both the diagnosis and the management were altered by the ultrasound results.

#### Case 2

A 66-year-old female with a medical history of diabetes mellitus and diabetic neuropathy presented with chronic left ankle pain. After the physical examination, the patient was believed to have an intact Achilles tendon but probable tendinopathy as the cause of her symptoms. The initial treatment plan was conservative, including bracing. An ultrasound examination was performed, which demonstrated a partially torn Achilles tendon and a torn plantaris tendon (Fig. 2). In this case, the diagnosis changed after the ultrasound examination, but the treatment plan did not.

#### Case 3

A 64-year-old female presented to a podiatrist with chronic left foot pain described as "walking on a pebble." On physical examination, tenderness to palpation was present at the third intermetatarsal

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