Sonography of Morton Neuromas

What Are We Really Looking At?

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Objectives—To determine what accounts for the sonographic appearance of a Morton neuroma by correlating preoperative sonograms with the sonographic appearance of the resected surgical specimen, the surgical findings, and the pathologic examination.

Methods—Ten Morton neuromas that had preoperative sonograms underwent postoperative specimen sonography and histologic evaluation. The appearance and size of the neuromas were compared between the preoperative and postoperative specimen images and were compared to the surgical and pathologic appearances.

Results—Preoperative images showed a fibrillar echogenic nerve coursing into a heterogeneous hypoechoic mass measuring 14.3 mm in average length (range, 9.0–24.0 mm) that contained a round, mildly echogenic mass within it measuring 7.6 mm in average length (range, 4.5–12.0 mm). Surgically, the specimens showed scarred intermetatarsal bursas and tangled vessels surrounding the nerve. Specimen sonography showed echogenic focal enlargement of the nerve at the site of the neuroma, measuring 6.8 mm in average length (range, 3.5–11.0 mm). The size of the resected neuroma was smaller than the hypoechoic mass on the presurgical images ($P < .001$). Within the hypoechoic mass, the small echogenic focus showed no difference in size compared to the specimen ($P = .40$), but the shape of the echogenic specimen was fusiform, whereas the preoperative appearance was round. Histologically, the resected specimens showed sclerosis and mucoid degeneration of the nerve fascicles and fibrotic thickening of the perineurium.

Conclusions—The hypoechoic heterogeneous mass that is referred to as a Morton neuroma sonographically is really a "neuroma-bursal complex" that is much larger than the actual neuroma itself.

Key Words—Morton neuroma; musculoskeletal ultrasound; sonography

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Morton neuromas are commonly encountered sources of foot pain, with a reported prevalence of up to 33%,[1,2] and patients often feel pain radiating to the toes or numbness on either side of the web space.[3] A Morton neuroma is routinely diagnosed clinically in patients with a history of radiating electrical pain to the involved toes, which is made worse with tight shoes or boots. The most common location in the web space is between the third and fourth toes (third web space). On physical examination, a Mulder click, which is a palpable catching of the neuroma with transverse compression of the metatarsal heads, is suggestive as well.[4] Imaging is often performed to confirm a suspected diagnosis of a Morton neuroma or to clarify the correct web space of a neuroma,

since up to 28% of Morton neuromas are located in a web space adjacent to the one suspected clinically.[5] Two recent meta-analyses of the literature reported equal sensitivity of magnetic resonance imaging and sonography for detecting these lesions.[6,7]

Although the sonographic appearance of Morton neuromas has been reported as a hypoechoic process,[8–11] our foot and ankle surgeons have anecdotally reported to us that the heterogeneous hypoechoic mass that we call a Morton neuroma sonographically often overestimates the size of the lesion surgically. This discrepancy in size between sonography and surgery was also reported by Read et al[9] and Jones et al,[12] but without explanations for the difference. The purpose of our study was to determine what accounts for the clinical sonographic appearance of a Morton neuroma by correlating the preoperative sonographic appearance with the sonographic appearance of the resected surgical specimen, the surgical findings, and the pathologic examination.

Materials and Methods

This prospective study received approval from our Institutional Review Board with waiver of informed consent. Ten Morton neuromas excised between October 2013 and April 2014 that had preoperative sonograms were evaluated. Patients with prior surgery on the web space or without preoperative sonographic examinations were excluded.

All preoperative examinations were performed with iU22 scanners (Philips Healthcare, Bothell, WA) using either 17- or 12-MHz linear transducers. All preoperative sonograms were obtained by our routine scanning protocol for neuromas: chroma (colored) scale images were obtained in the long axis from both dorsal and plantar approaches (Figure 1) by musculoskeletal sonographers with a minimum of 3 years of musculoskeletal ultrasound experience.

At surgery, the neuromas were excised from a dorsal approach, placed between 0.9% saline-soaked gauze pads in a specimen container, and brought to the sonography suite by one of the authors. Before scanning the resected specimen and blinded to the gross appearance of the specimen, a musculoskeletal radiologist (T.T.M.) with 17 years of musculoskeletal ultrasound experience retrospectively evaluated the preoperative images and measured the overall long-axis length of the hypoechoic abnormality and long-axis length of the suspected neuroma itself. Visualization was always best on the images obtained via the plantar approach, and measurements were made on images that did not have manual compression of the bursa.

Sonography of the specimen itself was then performed by this same musculoskeletal radiologist by placing the specimen within a thick bed of ultrasound gel (Figure 2; Aquasonic 100 water-soluble ultrasound transmission gel; Parker Laboratories, Fairfield, NJ) and using a 17-MHz linear probe in the long axis plane using both gray and Chroma scales. The images of the specimen were then assessed by the radiologist for the long-axis length of the neuroma and appearance. The specimen was then taken by one of the authors to the Department of Pathology for routine gross and histologic evaluation.

The appearance and length of the neuromas were compared between the preoperative and postoperative images and were compared to the surgical and pathologic appearances. Two-tailed paired Student *t* tests compared the preoperative and resected specimen lengths, as measured by the musculoskeletal radiologist on the picture archiving and communication system using electronic calipers in the long-axis plane. $P < .05$ was considered significant.

Results

The average patient age was 55 years (range, 45–65 years). Ten Morton neuromas were evaluated from 8 patients, 2 of whom had neuromas removed from each foot. The time difference between the preoperative and specimen sonography ranged from 1 day to 6.5 months, with an average interval of 3 months. Five specimens were from 3 male patients, and 5 specimens were from 5 female patients. Four specimens were from the second metatarsal space, whereas 6 specimens were from the third metatarsal space.

Surgically, all cases had thickened or scarred bursal tissue around the nerve and interdigital vessels that had to be disentangled from the nerve (Figure 3). All specimens were pathologically proven as Morton neuromas; they showed focal thickening of the nerve at gross examination and sclerosis and mucoid degeneration of the nerve fascicles and fibrotic thickening of the perineurium histologically (Figure 4).

Preoperative images in the longitudinal plane showed a normal fibrillar echogenic nerve coursing into a focal heterogeneous hypoechoic mass within the web space, which measured 14.3 mm in average length (range, 9.0–24.0 mm) and contained an echogenic mass within it, which measured 7.6 mm in average length (range, 4.5–12.0 mm; Figure 5). Longitudinal sonography of the specimens showed echogenic focal enlargement of the nerve, measuring 6.8 mm on average (range, 3.5–11.0 mm).

The length of the resected neuroma in the long-axis plane was significantly smaller than the hypoechoic mass

Figure 1. Clinical photograph showing sonography of the second web space from the plantar approach.

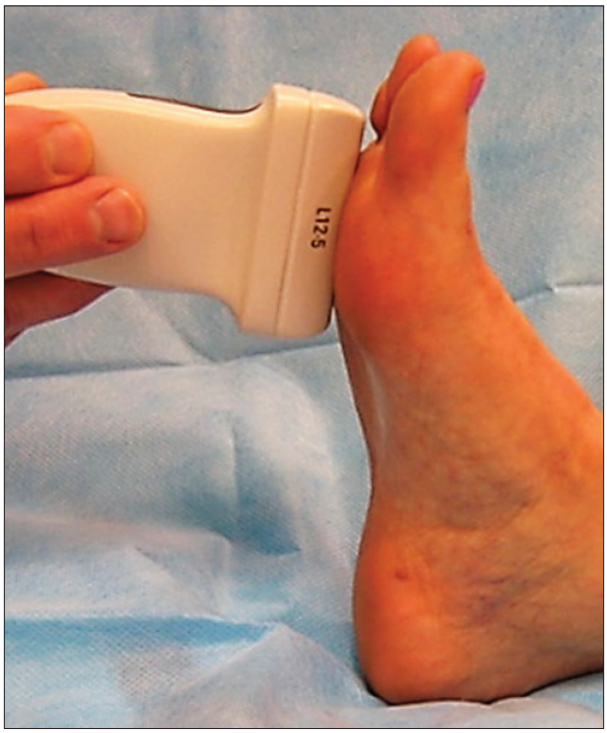


Figure 2. Resected surgical specimen in a bed of ultrasound gel. Arrow designates the neuroma.

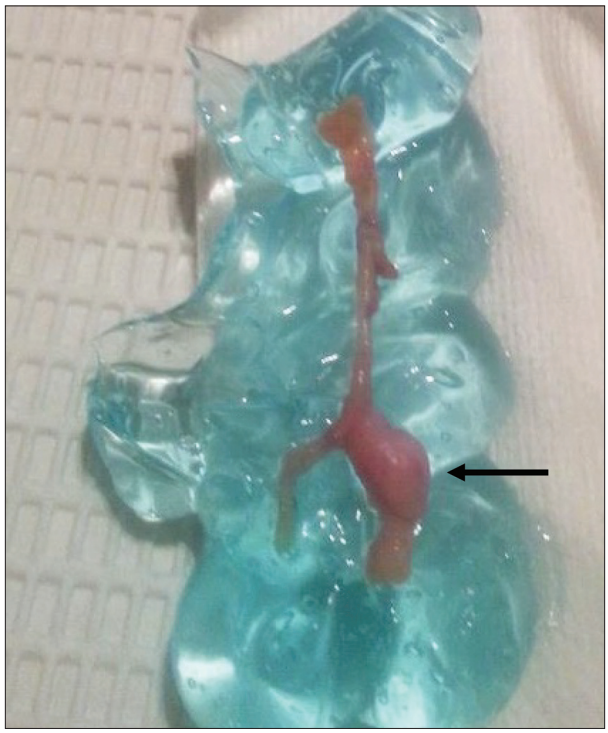
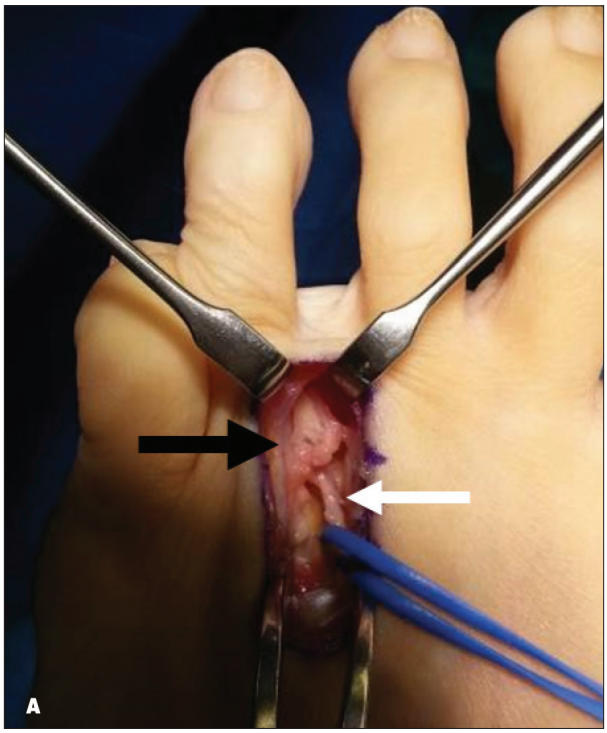
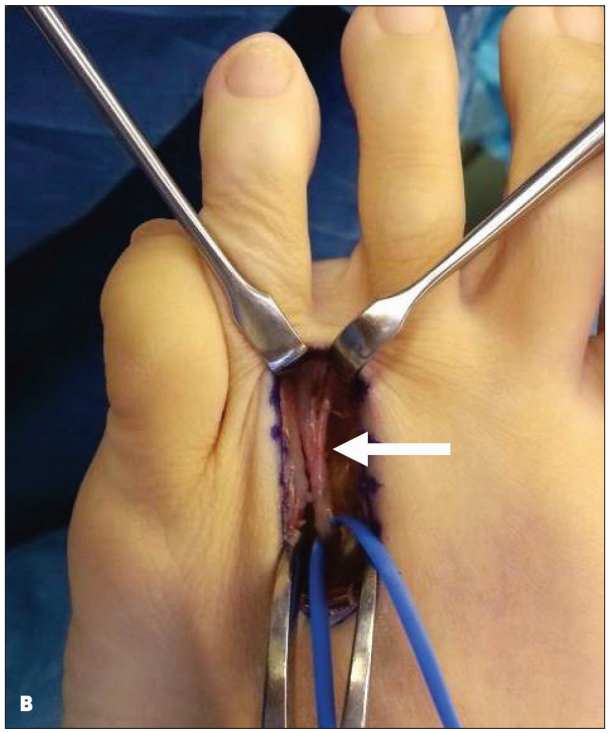


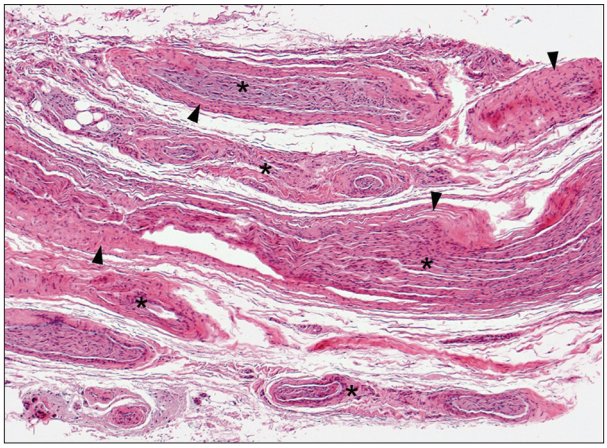
Figure 3. Intraoperative photographs during resection. **A**, Nerve (white arrow) with surrounding scarred bursal tissue (black arrow). **B**, Nerve (white arrow) after resection of scarred surrounding tissue.





on the presurgical images ($P < .001$). However, the small echogenic focus within the hypoechoic mass corresponded to the size of the resected echogenic specimen with no statistically significant difference ($P = .40$), but the shape of the in vivo echogenic mass was round, whereas the resected specimen was fusiform.

Figure 4. Histologic specimen of neuroma (hematoxylin-eosin, original magnification ×10). Asterisks designate nerve bundles with fibrosis and mucoid degeneration; and arrowheads designate perineural fibrous thickening.

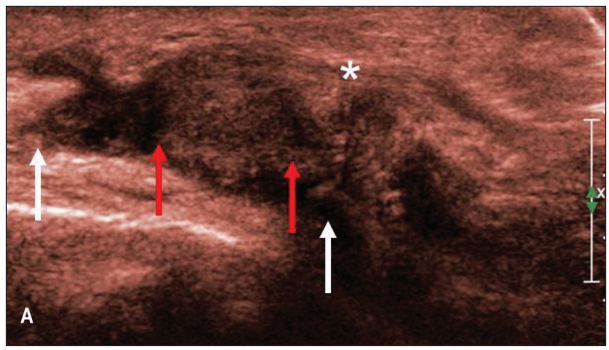


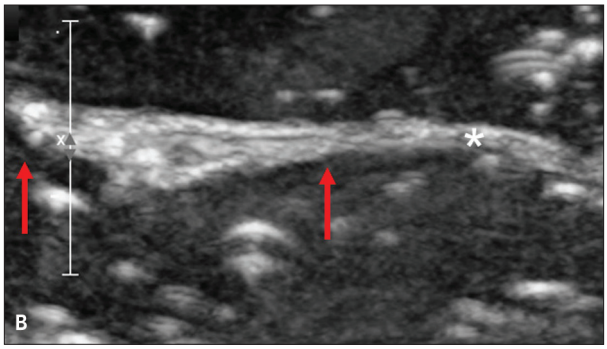
Discussion

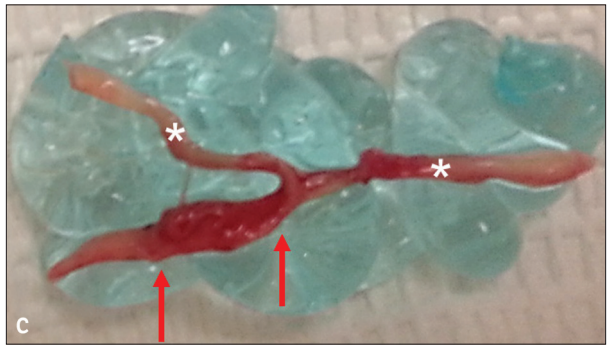
This study sought to clarify the sonographic appearance of a Morton neuroma. We found that the heterogeneous hypoechoic intermetatarsal mass that is sonographically considered a Morton neuroma is actually a "neuroma-bursal complex" consisting of the thickened degenerated nerve, fibrotic perineurium, tangled vessels, and scarred/thickened bursa, which is significantly larger than the actual neuroma itself. Within this complex is a mildly echogenic mass that corresponds in size, but not in shape, to the actual neuroma. This difference in shape is most likely due to scar tissue around the nerve that is dissected away during surgical resection. Similar histologic components of the complex have been described by others.[9]

Other investigators have also reported discrepancies between the preoperative sonographic size of the neuroma and the specimen. In a study of 20 pathologically proven Morton neuromas that had been scanned longitudinally from a dorsal approach, Read et al[9] reported that sonography could not definitely separate the neuromas from adjacent mucoid degeneration in 19 specimens, and their surgeons commented that the sonographic measurements were larger than the specimens. However, the authors did not mention the sizes in their article, nor did they scan the actual specimens after surgical resection.

Figure 5. Images from a 65-year-old woman with Morton neuroma. **A**, Long-axis presurgical chroma scale sonogram, **B**, Long-axis specimen sonogram, **C**, Specimen in ultrasound gel. Asterisks designate the nerve in all 3 images; white arrows designate the neuroma-bursal complex in **A**; and red arrows designate the neuroma in all 3 images.







Similarly, another study of 38 pathologically proven Morton neuromas also found that the mean diameter of the neuroma on preoperative sonography in both short and long axes from a plantar approach was larger than the resected surgical mass.[12] In a foreshadowing of our work, those authors described neuromas as hypoechoic structures containing central solid components, and they concluded that sonography was useful for localizing and diagnosing a Morton neuroma but not for accurately measuring it. Imaging of the specimens was not performed in their study.

Historically, the magnetic resonance imaging literature has reported that neuromas larger than 5 mm in the transverse dimension tend to be symptomatic, with varying prevalence of bursal components,[1,2] but magnetic resonance images lack the ability to discern the scarred nerve and surrounding bursal tissue. Bursal thickening and fluid distension were present in all of our cases in this study, both sonographically and surgically, and are always present in our clinical cases. Thus, the reported overall size of the abnormality is really a combination of neural degeneration, perineural scarring, and bursal elements, which according to our surgeons makes size criteria less discriminatory for surgical intervention and emphasizes the importance of the physical examination and patient history. In addition, knowledge of the sonographic components of the abnormality may help guide percutaneous intervention, with steroid injections targeting the bursal component and ablation procedures targeting the scarred and degenerated nerve.

The major limitation of our study was the small number of cases; most of the neuroma resections at our institution are done at off hours (ie, weekends or evenings), when imaging of the specimens is not available. Although the radiologist made his measurements of the preoperative images blinded to the resected specimen, he was not blinded to the preoperative appearance when assessing the specimen, but we do think this factor was a limitation, since we were trying to correlate the appearances of the preoperative and resected pathologic specimens to determine what accounted for the preoperative appearance. We made no attempt to correlate the size of the neuromas with symptoms, as that was not the objective of our study, but all were symptomatic and diagnosed clinically, prompting surgical treatment, and our web space distribution of neuromas is consistent with the literature.[1,11] Last, we do not think that the discrepancy in the appearance of the process is a function of plantar imaging and dorsal surgery, since the resected specimen would look the same regardless of the approach by which it was removed.

In conclusion, the hypoechoic heterogeneous mass that is referred to as a Morton neuroma is really a neuroma-bursal complex, reflecting a combined appearance of the degenerated nerve, perineural scarring, tangled vessels, and scarred intermetatarsal bursa, and is much larger than the actual neuroma itself. We now use this term in our sonographic reports, and it has been accepted by our foot and ankle surgeons and podiatrists.

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