Ultrasound-Guided Decompression of the Intermetatarsal Nerve for Morton’s Neuroma

A Novel Closed Surgical Technique

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Background: This study describes the technique for decompression of the intermetatarsal nerve in Morton’s neuroma by ultrasound-guided surgical resection of the transverse intermetatarsal ligament. This technique is based on the premise that Morton’s neuroma is primarily a nerve entrapment disease. As with other ultrasound-guided procedures, we believe that this technique is less traumatic, allowing earlier return to normal activity, with less patient discomfort than with traditional surgical techniques.

Methods: We performed a pilot study on 20 cadavers to ensure that the technique was safe and effective. No neurovascular damage was observed in any of the specimens. In the second phase, ultrasound-guided release of the transverse intermetatarsal ligament was performed on 56 patients through one small (1- to 2-mm) portal using local anesthesia and outpatient surgery.

Results: Of the 56 participants, 54 showed significant improvement and two did not improve, requiring further surgery (neurectomy). The postoperative wound was very small (1–2 mm). There were no cases of anesthesia of the interdigital space, and there were no infections.

Conclusions: The ultrasound-guided decompression of intermetatarsal nerve technique for Morton’s neuroma by releasing the transverse intermetatarsal ligament is a safe, simple method with minimal morbidity, rapid recovery, and potential advantages over other surgical techniques. Surgical complications are minimal, but it is essential to establish a good indication because other biomechanical alterations to the foot can influence the functional outcome. (J Am Podiatr Med Assoc 110(6): 1-9, 2020)
Diagnosis

Accurate and complete diagnosis is required for successful treatment; as with forefoot pathology, there are frequently multiple pain generators, such as a torn plantar plate. Clinical history associated with physical examination, such as a Mulder’s test with sensitivity of 94% to 98% (Fig. 1), is essential.10-12

Imaging tests (magnetic resonance imaging [MRI], ultrasonography, and radiography) can help confirm the diagnosis of MN or exclude other causes of pain in the forefoot, such torn plantar plate, capsulitis, joint disease, Freiberg’s disease, or metatarsalgia, among others.3,13

The available evidence suggests that ultrasonography is more precise than MRI for diagnosing MN. Grouped sensitivity analysis shows a similarity between ultrasonography (90%) and MRI (93%), which are both relatively high; however, MRI (68%) has relatively lower specificity than ultrasonography (88%) in detecting MN.14

With ultrasonography, MN is detected as a well-defined round or ovoid mass on the short axis and a long/fusiform mass in the long axis view; it is hypoechoic in relation to adjacent tissues and is located between the metatarsal heads along the plantar view of the intermetatarsal spaces.15 The forefoot compression maneuver helps extrude the intermetatarsal content toward the plantar view of the forefoot, providing a better view of the MN. This displacement may coincide with a palpable and/or audible click, known as “Mulder’s sign.”15

Treatment

Morton’s neuroma is generally treated conservatively, first with modified footwear, orthoses, physiotherapy, and anti-inflammatory drugs, followed by a second step, such as percutaneous therapies such as corticosteroid injections, sclerosing injections with alcohol, and radiofrequency ablation.6,16-18

Surgery is usually reserved for patients with recalcitrant pain unalleviated by conservative measures.19-22 Numerous surgical procedures have been described for MN, such as neurolysis, excision with interpositional nerve grafting, dorsal suspension for MN, and metatarsal osteotomies associated with transverse intermetatarsal ligament (TIML) release. The most widely practiced are neurectomy and TIML release.20,21,23-28

Numerous authors justify TIML decompression as the first option for MN surgery, without the need for a neurectomy, because the pathology is seen as a compressive neuropathy, and, therefore, decompression and neurolysis should be the first approach, as with any peripheral neuropathy. Neurectomy should be reserved for patients in whom TIML release fails.29,30

Decompression of the TIML can be performed by open, endoscopic, or ultrasound-guided surgery, as described herein, in which a 1- to 2-mm portal was used in the interdigital zone.20,21,25-27

In 1979, Gauthier31 was the first author to report his results on decompression by division of the TIML and epineurolysis in more than 206 patients with 304 nerve lesions. Of these patients, 83% reported rapid and stable improvement, and an additional 15% improved but still experienced some pain. Weinfeld and Myerson32 also supported division of the TIML without neurolysis. The advantage of TIML division without excision of the neuroma is that there is no loss of sensation or possible subsequent formation of a stump neuroma, which is more difficult to treat than the original lesion.3,13,32

In 1994, Barrett and Pignetti25 introduced endoscopic decompression of the intermetatarsal nerve (EDIN). Its advantages are smaller incisions, faster recovery, less postoperative pain and swelling, and a lower rate of hematoma and infection.20,26,27 Barrett and Walsh26 reported good or excellent results with EDIN in 91.3% of patients, but the instrumentation they developed is delicate and the learning curve is steep, three incisions are required, and the nerve cannot be visualized.

In this article, we describe ultrasound-guided decompression of the intermetatarsal nerve (US-DIN) for release of the TIML as an attractive option because it can be performed with local anesthesia through a single 1- to 2-mm incision as outpatient surgery and has faster recovery times. The aim of

Figure 1. Mulder’s test.
this study was to describe the surgical technique and preliminary results during surgical training on cadavers and on patients.

Materials and Methods

Study Design

This prospective study was performed in accordance with the principles of the Declaration of Helsinki (2013 revision). The Anatomy Department of Ramon y Cajal University Hospital (Madrid, Spain) provided the specimens used in this cadaveric study.

In the initial training for the USDIN technique, we performed a pilot study with 20 cadavers to ensure that the technique was safe and effective. No neurovascular damage was observed in any of the specimens. In the second phase, we used the USDIN technique to release the TIML in 56 patients, two of which involved bilateral surgery (58 feet). The indication for surgery was MN diagnosed by clinical examination and imaging tests, using ultrasonography. Excluded from the study were patients who had or might have had another associated pathologic disorder, such as metatarsalgia, or a functional and/or structural alteration that could cause pain in the forefoot, such as cavus foot or calf shortening, because these conditions can lead to pain in the forefoot and may be a factor for a worse prognosis. Postoperative follow-up was at 1, 3, 6, and 12 months.

The study population consisted of 49 women and seven men with a mean age of 54 years. All of the patients had previously received conservative treatment, including modifications to footwear, physiotherapy, tailored plantar orthoses, and corticosteroid injections. The mean duration of symptoms ranged from 3 to 5 years.

Surgical Technique

The basis of the USDIN technique has been previously reported.33,34 We have described various ultrasound-guided procedures in the scientific literature, including partial plantar fasciotomy, proximal and distal tarsal tunnel release, and proximal and distal calf lengthening. The working and systematic principles for TIML release are similar to those for the other techniques described.33-35

The instrumentation used includes long needles (a 20-gauge, 0.9 × 90-mm-diameter BD spinal needle; Becton Dickinson S.A., Madrid, Spain), two V-shaped straight curettes (Nos. 1 and 2), a blunt dissector, a 3-mm retrograde hook knife (Smith & Nephew, Watford, England), and an ultrasound device (E-Cube 15; Alpinion Medical Systems, Anyang, Korea) with an 8- to 17-MHz linear transducer with the Needle Vision Plus software package36 and betadine gel (Fig. 2).

We always perform the procedure with two surgeons. Thus, the first surgeon can concentrate on accurate positioning of the instruments and make the incision using two hands to steady the scalpel. The second surgeon can hold the probe and assist with technical procedures or insertion of the instruments.

Ultrasound-guided release of the TIML is performed with the patient in the supine position. No tourniquet is required, and local anesthesia is used. In the first surgical stage, a dorsal long-axis ultrasound examination is performed to locate the important structures in the procedure: the MN, the interosseous muscle, and the TIML (Fig. 3).

Once the structures are located in the long-axis ultrasound, an interdigital approach is made with the needle to inject the anesthesia between the MN and the TIML. This step is important because it provides anesthesia and dissects the planes by volume of injected anesthesia, which as approximately 5 mL of 1% mepivacaine (Fig. 4).

The second stage consists of inserting V-shaped straight curettes (Nos. 1 and 2) consecutively, with the aim of broadening the entry point and facilitating entry of the hook knife (Fig. 5). The whole procedure is viewed by ultrasonography (Fig. 6).

In the third stage, the hook knife is inserted using the No. 2 curette as a guide to facilitate its entry into the skin (Fig. 7). Once the scalpel is inserted in the skin and guided by ultrasound with a dorsal approach long-axis view, the MN and TIML are approached as far as the most proximal strip, where the hook knife is rotated in the dorsal direction and withdrawn, thereby cutting the TIML (Fig. 7). During this stage, dorsal to plantar pressure is exerted on the metatarsal heads to tense the TIML.

In the fourth and final stage, the blunt dissector is inserted to check that the resection of the ligament

Figure 2. Instrument set.
Figure 3. Dorsal approach long-axis ultrasound image of the third intermetatarsal space. The Morton’s neuroma (MN), transverse intermetatarsal ligament (TIML), and interosseous muscle (IM) are located.

Figure 4. Injection of local anesthesia between the transverse intermetatarsal ligament (TIML) and the Morton’s neuroma (MN). IM, interosseous muscle.

Figure 5. Introduction of V-shaped straight curettes (Nos. 1 and 2) between the transverse intermetatarsal ligament and the Morton’s neuroma.
is complete, using ultrasonography to observe that the dissector can pass easily through the space in the plantar to dorsal direction without resistance from the TIML (Fig. 8). No sutures are required. We use adhesive strips to seal the 1- to 2-mm incision, a compressive bandage, and a postsurgical shoe for 1 week (Fig. 9). The patient can walk with the aid of a crutch for 3 to 7 days after surgery.

Results

The American Orthopaedic Foot & Ankle Society (AOFAS) forefoot score and a visual analog scale (VAS) were used for preoperative and postoperative function and pain evaluation 1, 3, 6, and 12 months after surgery. Statistical analysis was performed using SPSS for Windows, Version 11.0 (SPSS Inc, Chicago, Illinois), and statistical significance was set at $\alpha < .05$ using a 2-tailed test.

The neuroma was alleviated in 54 of the 56 patients undergoing TIML decompression by ultrasound-guided surgery. Pain and function improved significantly. The mean preoperative VAS score was 7 (range, 6–9), which improved to 2.66 at 3 months, 1.88 at 6 months, and 0.5 at 12 months. The AOFAS ankle-foot score improved to a mean of 32.4 at 1 month, 70.1 at 3 months, 79.69 at 6 months, and 95.33 at 1 year. The improvement in pain and function was significant at 3 months ($P = .05$) and continued to improve to 12 months (Figs. 10 and 11).

Neither walkers nor crutches were required in the postoperative period, and patients could bear weight immediately. There was no loss of sensitivity or infection. Of the 56 patients, only two women did not improve and required a further neurectomy at 6 months.

The results of the study were satisfactory, with 54 patients (98.1%) improving; however, two patients (1.9%) failed to improve and required a neurectomy.
at 6 months. All of the patients developed mild superficial hematomas that resolved after 4 to 5 weeks, encouraging active mobility of the ankle and fingers without the need for adjuvant therapy (Fig. 12). There were no other surgery-related complications, such as infection.

**Discussion**

Surgical options for MN include TIML release, neurectomy, neurolysis, excision with interpositional nerve grafting, dorsal suspension for MN, and metatarsal osteotomies associated with TIML...
release. The most widely performed procedures are neurectomy and TIML release.\textsuperscript{20,21,23-30,37}

A variety of authors maintain that MN is a compressive neuropathy of the TIML.\textsuperscript{29,32,37} Gauthier, in 1979,\textsuperscript{31} was the first author to publish results on TIML resection, obtaining good results in 83\% and improvement in 15\% although still experiencing pain. Weinfeld and Myerson\textsuperscript{32} also support division of the TIML without neurolysis. Barrett, in 1994, introduced EDIN\textsuperscript{25} and in 2006 reported good or excellent results in 91.3\% of patients.\textsuperscript{26} The EDIN offers the advantages of smaller incisions, faster recovery, less postoperative pain and swelling, and a lower rate of hematoma and infection.\textsuperscript{26,27}

In 2008, Villas et al\textsuperscript{30} published a comparative retrospective study of TIML release and neurectomy in 69 feet, obtaining good results in both groups, thereby supporting TIML resection as the first surgical option, followed by neurectomy if pain persists.

Open procedures and endoscopic surgery require epidural anesthesia or trunk block and involve ankle-foot tourniquets and sutures. Endoscopic surgery for TIML decompression in MN seems to be less invasive, with a variety of advantages over open procedures: incisions are smaller, recovery time is faster, and there are fewer complications and less morbidity.\textsuperscript{20,25,26}

Decompression of the TIML avoids the complication of stump neuroma,\textsuperscript{3} which can occur with neurectomy and requires rescue surgery.\textsuperscript{38,39} Decompression of the TIML can be performed by open endoscopic\textsuperscript{4,20,21,25-27,40} or ultrasound-guided surgery, as described in this study, in which a 1- to 2-mm approach was used in the interdigital zone.

In the present study, the preoperative VAS score was 7 (range, 6–9), improving dramatically in first 3 months, continuing to improve at 6 months, and then improving more discreetly at 12 months to a VAS score of 0.5.

The AOFAS ankle-foot score went from 25.6 before surgery to 95.33 at 12 months after surgery. The improvement in pain and function was significant at 3 months and continued to improve to 12 months.

All of the patients had superficial hematoma that resolved after 4 to 5 weeks, and there were no complications, such as infection. Only two patients required further surgery at 6 months, undergoing a neurectomy.

The present results are very similar to those of other authors,\textsuperscript{19,20,26,29,30,32} as 98.1\% of the patients showed significant improvement. Only two patients (1.9\%) required further surgery, undergoing a neurectomy.

We have tried to limit the USDIN technique to MNs smaller than 1 cm in circumference in the short axis because we think that the size of the MN may be an important indication for performing a neurectomy or TIML resection and a possible area of future study to provide a better-defined and standardized protocol for action.

\textbf{Figure 12.} Superficial hematoma 1 day (A) and 1 week (B) after surgery.
Conclusions

We believe that this is the first description of ultrasound-guided TIML release for MN, which we term USDIN. Although we have found one published technical note on ultrasound-guided release of perineural fibrosis in MN by needle,20,21,25-27 no TIML release is performed.

The present conclusion is similar to that of other authors, whereby the first option for surgical treatment for MN is TIML resection using techniques as minimally invasive as possible. The USDIN technique could provide improvements over endoscopic surgery. It uses 1- to 2-mm incisions, without a tourniquet, using local anesthesia and outpatient surgery. The complications, such as infection, wound dehiscence, and postsurgical fibrosis, are reduced. Postoperative pain is minimal, thus speeding up recovery.20,21,25-27 Furthermore, the USDIN technique permits surgery on both feet in the same operation or the association of additional surgical procedures, such as calf lengthening.33

The USDIN technique for MN is a very simple procedure. To our knowledge, there is no publication about TIML decompression by ultrasound, this article being the first reference, and thus it describes a novel technique, improving on the advantages of the endoscopic technique.

We firmly believe that ultrasound-guided surgery for MN decompression is an ultra-minimally invasive procedure that reduces the size of the incision and ensures better healing, reduces postsurgical pain, uses local anesthetic, and does not require a tourniquet. Thus, it could contribute to reducing complications and contraindications and could speed up recovery.

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References
23. SONG JH, KANG C, HWANG DS, ET AL: Dorsal suspension for...


