Morton's Neuroma

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KEYWORDS

• Neuroma • Interdigital neuroma • Neuritis
• Nerve compression syndrome • Morton neuroma

The diagnosis and treatment of Morton's neuroma is common for the foot and ankle surgeon, and are included in the differential diagnosis of any patient who presents with forefoot pain. Specific symptoms of this disorder include complaints of shooting pain, numbness and/or tingling in the third and fourth digits, burning sensation, cramping, and a feeling of ''walking on a lump'' in the ball of the foot. Symptoms of pain with orgasm or defecation have also been reported.[1] Patients can also relate a decrease in symptoms with removal of shoe gear or massage of the forefoot.[2,3] The symptoms associated with a neuroma are typically of gradual onset and progressively get worse with time, but can be caused by trauma.[4,5] The term neuroma is a misnomer because it is not a neoplastic or proliferative process but a degenerative one.[6] The involved nerve histologically shows demyelination of its nerve fibers, fibrosis of the epineurium and endoneurium (**Figs. 1** and **2**), and densely packed whorls of collagen called Renaut bodies.[3]

ANATOMY

The anatomy of a Morton's neuroma is well known. The neuroma is actually a benign enlargement of the third common digital branch of the medial plantar nerve (**Fig. 3**). There is a communicating branch from the fourth common digital branch of the lateral plantar nerve prior to splitting into the plantar proper digital branches. This anatomy is countered by an anatomic study by Levitsky and colleagues,[7] which demonstrated absence of the communicating branch in 73.2% of the cadavers studied.[6] This nerve passes deep to the deep transverse metatarsal ligament. The enlargement or neuroma is usually located at the level of the third and fourth metatarsal heads but often can be found just distal to the metatarsal heads. In their anatomic study, Kim and colleagues[4] found that interdigital neuromas were located distal to the deep transverse metatarsal ligament in both the midstance and heel-off stage of ambulation. Other structures worth mentioning in the plantar third interspace include the third lumbrical tendon and muscle and the third plantar metatarsal artery and veins.

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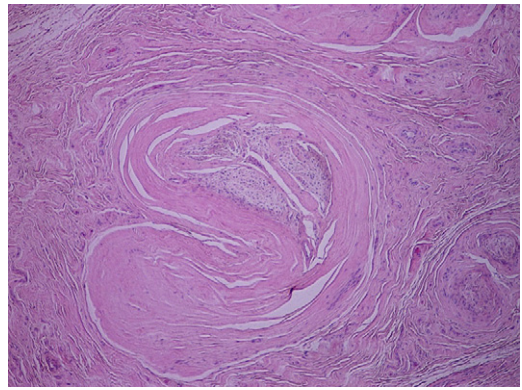

Fig. 1. Cross section of neuroma showing perineural and epineural fibrosis (hematoxylin and eosin, original magnification ×40).

HISTORY

Morton neuroma was first described by Durlacher in 1845. In 1876, Thomas G. Morton described a painful and peculiar affliction of the foot and was credited with its original description in most of the literature.[2] Morton neuroma has also been known by many names, including Morton toe, Morton metatarsalgia, Morton neuroma, interdigital neuroma, interdigital neuritis, and interdigital nerve compression syndrome.

PATHOGENESIS

Many theories have been proposed regarding the causes of this condition, which include ischemia,[8] presence of an intermetatarsal bursa,[3,9] pronation,[10] trauma,[6] and anatomic thickness of the nerve in the third interspace.[11] Recent data indicate that Morton neuroma is a nerve entrapment syndrome caused by mechanical impingement of the nerve by the deep transverse intermetatarsal ligament.[6,12,13] This observation was questioned by Kim and colleagues,[4] who found in an anatomic study that the main nerve lesion was located distal to the deep transverse metatarsal

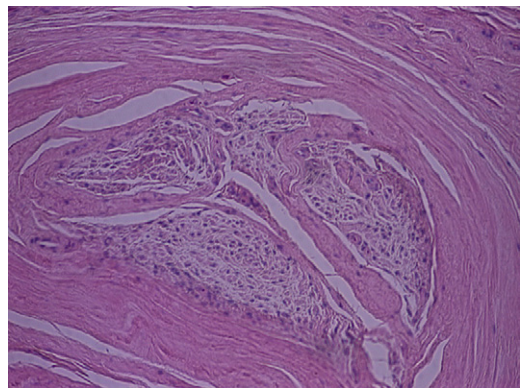

Fig. 2. Cross section of neuroma showing perineural and epineural fibrosis (hematoxylin and eosin, original magnification ×100).

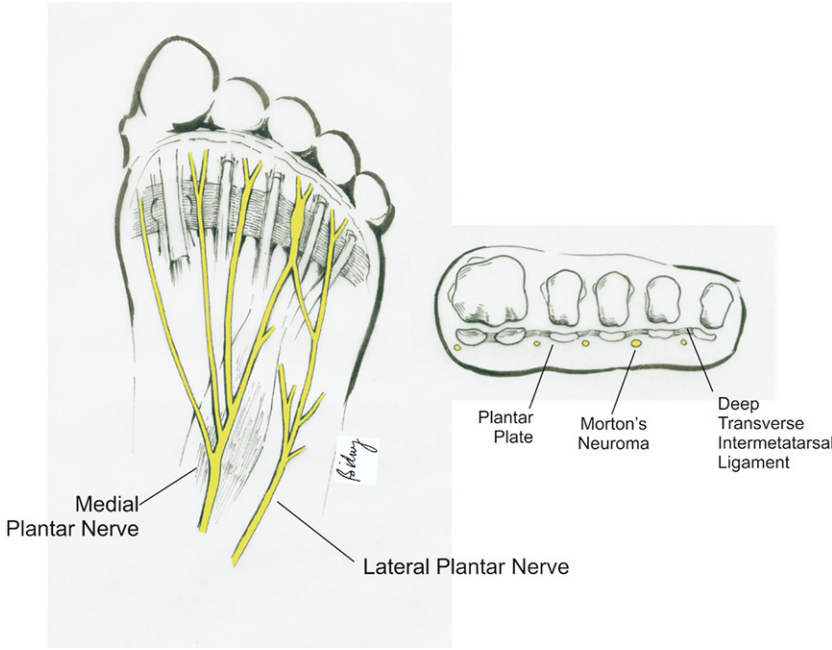

Fig. 3. Anatomy of the plantar nerves and the relationship of Morton neuroma to the deep transverse metatarsal ligament. (*From* Thomas JL, Blitch EL IV, Chaney DM, et al. Diagnosis and treatment of forefoot disorders. Section 3. Morton's intermetatarsal neuroma. J Foot Ankle Surg 2009;48(2):253; with permission.)

ligament in the both midstance and heel-off phases of gait. The investigators postulated that the condition was caused by pinching of the common digital nerve by the adjacent metatarsal heads and metatarsophalangeal joints during walking.

Barrett and Jarvis[14] pointed out that equinus deformity should be considered as a cause for nerve entrapment or neuroma. It is well established that equinus deformity increases forefoot plantar pressures. In diabetic patients, this increase in pressure is a risk factor for ulceration, which may be a contributing factor for the development of nerve entrapment or neuroma.

DIAGNOSIS

The diagnosis of Morton neuroma is mainly clinical and includes a thorough history and physical examination. The condition is more common in women than in men and is usually diagnosed between 40 and 60 years of age. A classic Mulder click can be palpated in the third interspace, with simultaneous medial to lateral compression of the forefoot with one hand and dorsal to plantar pressure on the third interspace with the opposite hand. This click is appreciated when the neuroma is pushed plantar by the third and fourth metatarsal heads.[2,3,15] A thorough examination of the metatarsophalangeal joints is helpful to rule out joint pathology. Neuroma formation can be appreciated in the second interspace but rarely in the first or fourth interspace. Most studies found the third interspace most common, but one well-documented study found an equal distribution between second and third interspace neuromas.[2]

Although the diagnosis is clinical, imaging modalities, such as radiography, magnetic resonance imaging (MRI), and ultrasonography, can play a role in diagnosis. Radiographs are mainly used to help rule out differential diagnoses such as avascular necrosis, osteoarthritis, fracture, or stress fracture. Splaying of the digits on a weight-bearing radiograph has been appreciated.[16] Some investigators believe that a neuroma can occasionally cast a faintly radiopaque shadow on plain-film radiographs.[17]

MRI can be useful to exclude other masses or pathology in the area but is not generally necessary for diagnosis of neuroma. On MRI examination, a neuroma can be seen as a mass that has low signal intensity on T1- and T2-weighted images, between or just distal to the metatarsophalangeal joints.[18] This low signal intensity results from the fibrous content of the neuroma, which distinguishes it from a neoplasm, such as a schwannoma or an intermetatarsal bursa, both of which appear hyperintense on the T2-weighted image.[19]

Ultrasonography has emerged as a valuable diagnostic tool. It is much less expensive than an MRI evaluation and can be performed in both office and hospital settings. A neuroma appears as an ovoid mass parallel to the long axis of the metatarsals. The mass has a hypoechoic signal and is best observed in the coronal view.[20–24] Ultrasound is also useful to rule out pathology of surrounding soft tissue structures quickly and easily.[25] Kankanala and Jain,[22] showed that the probability that ultrasonography will confirm the presence of plantar intermetatarsal neuroma is 91.67%. Their results revealed a sensitivity of 91.48%, a specificity of 100%, and 100% positive and 20% negative predictive values. Ultrasonography has also been used for guidance with both corticosteroid and alcohol sclerosing–type injections as treatment for intermetatarsal neuromas.[26]

Electromyography and nerve conduction velocity are useful tools when nerve pathology from a more proximal site is suspected or in patients with an atypical presentation.[3]

Other differential diagnoses that need to be excluded before treatment include tarsal tunnel syndrome, lumbar radiculopathy, peripheral neuropathy, capsulitis, bursitis, and metatarsalgia.

NONSURGICAL TREATMENT

Nonsurgical management is aimed at decreasing pressure and irritation of the nerve. This method includes avoiding high-heeled shoes and changing to a shoe with a wide toe box. Metatarsal pads placed just proximal to the metatarsal heads can help alleviate pressure and assist in spreading the metatarsal heads (**Fig. 4**). Orthotics can also be used. Bennett and colleagues[27] reported that 41% of the patients treated in their study improved with these measures alone. Oral nonsteroid and steroid medications may be used to decrease pain and inflammation. Corticosteroid and local anesthetic combination injection is commonly used. Typically, 1 to 3 injections are given. Success rates with corticosteroid injections vary greatly. Rassmussen and colleagues[28] found a success rate of 80% initially, but at 4-year follow-up only 11% of patients had lasting relief. Mann and Reynolds[2] found that corticosteroid injections neither provided lasting relief nor had predictable results. By contrast, Greenfield and colleagues[29] found that 80% of the patients who were studied indicated complete relief of pain or only slight pain at 2-year follow-up of a series of corticosteroid injections. Marcovic and colleagues[30] found that 26 of 39 patients (66%) had a positive outcome 9 months after a single ultrasound-guided cortisone injection. Saygi and colleagues[31] compared shoe gear modification along with a metatarsal pad with

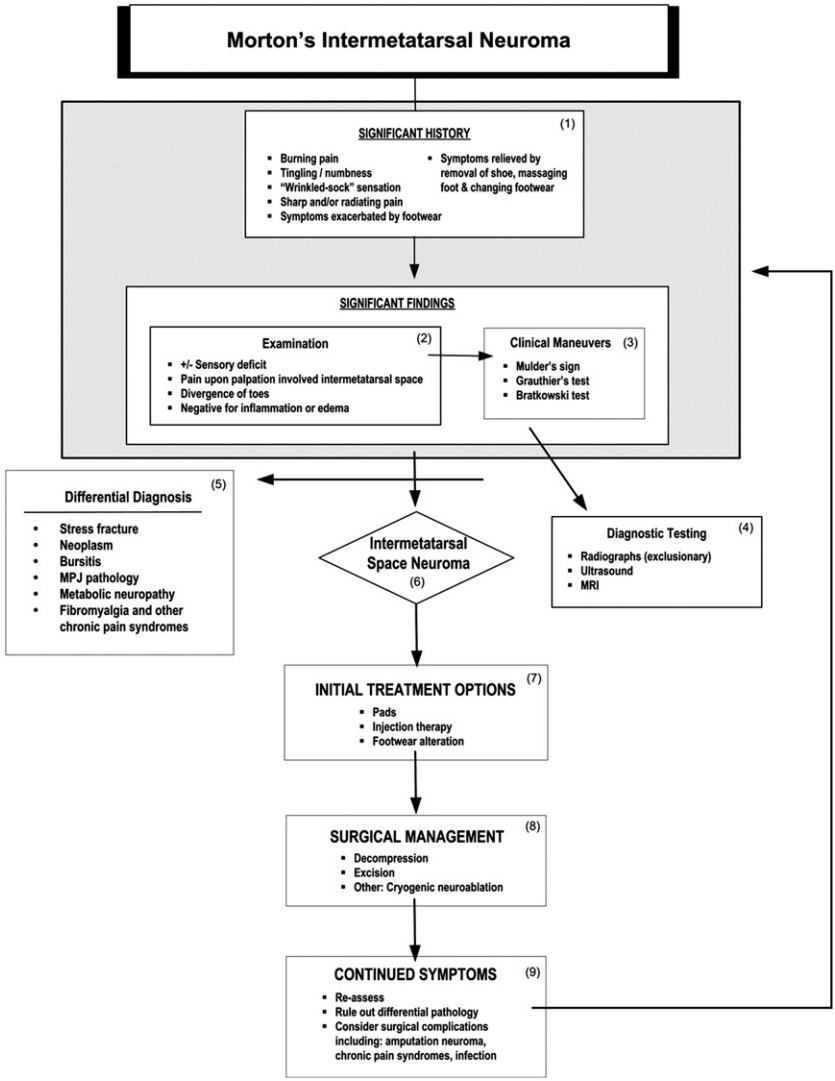

Fig. 4. Clinical practice guideline algorithm for Morton intermetatarsal neuroma. (*From* Thomas JL, Blitch EL IV, Chaney DM, et al. Diagnosis and treatment of forefoot disorders. Section 3. Morton's intermetatarsal neuroma. J Foot Ankle Surg 2009;48(2):252; with permission.)

steroid injection. These investigators found significantly higher patient satisfaction at 1, 6, and 12 months in the steroid injection group. At 12-month follow-up, 82% of those treated with steroid injections had complete or partial relief of pain compared with 63% of those with shoe gear modifications and metatarsal pads alone.

Injection of a 4% alcohol sclerosing solution has shown a success rate of 89%, with 82% of patients relaying complete relief of their symptoms. This injection was given in a series of 3 to 7 injections at 5- to 10-day intervals.[32] Several other studies have verified the effectiveness of alcohol sclerosing injections.[33,34] Corticosteroid and alcohol

sclerosing injections have been used under ultrasound guidance. Hughes and colleagues[26] achieved partial or total pain relief in 94% of patients, with 84% totally pain free in a series of 101 patients undergoing alcohol sclerosing injection under ultrasound guidance. These patients had an average of 4.1 treatments and an average follow-up of 10.5 months after the last injection.

Phenol has also been described as a safe and effective injection modality for the treatment of Morton neuroma.[35] Injection of cyanocobalamin has been reported in the literature, but the effects may have been due to benzyl alcohol, the preserving agent.[36]

Extracorporeal shockwave therapy (ESWT) has also been described as an alternative to surgical excision for Morton neuroma. Fridman and colleagues[37] studied 25 patients, of whom 13 were undergoing ESWT and 12 were in a sham group. The group treated with ESWT showed a significant difference in visual analog score before and after therapy; the sham group did not have a significant difference after 12 weeks. Four of the 13 patients treated with ESWT went on to surgical excision.

SURGICAL MANAGEMENT

When conservative management fails and pain persists, surgery becomes the treatment of choice. There is debate about what type of surgery and even what approach are most effective. Surgical excision remains the most common procedure for Morton neuroma. It is most commonly performed through a dorsal or plantar longitudinal incision approach, although transverse plantar, web splitting, and Y-incision approaches have been described. There are a small number of studies that compare plantar versus dorsal approach for neurectomy. Akermark and colleagues[38] concluded that both the approaches were comparable for clinical outcome and patient satisfaction. However, there were significant differences regarding the residual sensory loss and number of complications in favor of the plantar approach. The most notable complication from the dorsal approach was 3 missed nerves.

Although these procedures are essentially the same, with the same goal of neurectomy, differences exist in the dissection as well. With the dorsal approach, all of the dorsal soft tissue structures must be mobilized (**Fig. 5**). The deep transverse metatarsal ligament is released (**Fig. 6**). A lamina spreader is typically used to spread the third and fourth metatarsals. The nerve is the identified and dissected distally to the bifurcation. The digital nerves are transected distal to the bifurcation, then followed proximally and transected as proximally as possible (**Fig. 7**). Amis and colleagues[39] recommended that the nerve be excised at least 3 cm proximal to the deep transverse metatarsal ligament. Postoperatively, these patients may ambulate in a surgical shoe immediately. In contrast, the dissection from a plantar approach is simple. The nerve is readily available deep to the plantar fascia, and thus traumatic dissection through the interspace and retraction of muscle and bone during the procedure is avoided. These plantar incisions should be placed in non–weight-bearing positions between the metatarsal heads. Surgeons are often tentative about making plantar incisions for fear of hypertrophic painful scars; this has not been proved in the literature. Some surgeons advocate non–weight bearing for 2 to 3 weeks after surgery. In the Akermark study, patients in the dorsal and plantar incision groups were allowed weight bearing at 2 to 3 days.[38]

Another Surgical treatment for Morton's neuroma is nerve decompression. This can be performed open, with a minimally invasive incision or endoscopically. Nerve decompression is performed by releasing the deep transverse metatarsal ligament. Proponents of this procedure point out that Morton neuroma is not a true neuroma

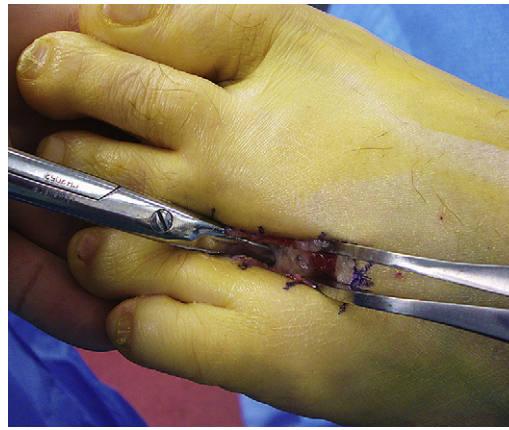

Fig. 5. Excision of neuroma by a dorsal approach. Scissor is deep into the deep transverse intermetatarsal ligament, prior to release.

but a nerve compression or entrapment syndrome. Furthermore, when the nerve is excised and resected, a true neuroma is then produced.[40–42] The endoscopic procedure described by Barrett is a 3-portal approach, with a 2.3-mm 30° scope. The dorsal portal allows for placement of a metatarsal retractor, which places tension on the deep transverse metatarsal ligament and hence allows for easier visualization and transection. A second incision is placed transversely in the web space, which allows for placement of the cannula beneath the deep transverse intermetatarsal ligament. The third incision is placed in a non–weight-bearing area of the arch through which the cannula passes as it exits the foot. Once visualized, the deep transverse intermetatarsal ligament is transected using a curved hook blade.[6,43]

In their retrospective study, Villas and colleagues[44] performed neurectomy by a dorsal approach, when macroscopic thickening of the nerve was present and observed intraoperatively. If no macroscopic changes were identified, the deep transverse intermetatarsal ligament and any other potentially compressive structure were released and the nerve was left intact. The nerve was excised in 46 of the 69 cases;

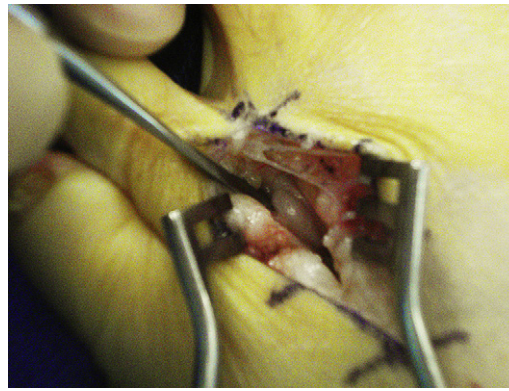

Fig. 6. After release of the deep transverse intermetatarsal ligament, the neuroma becomes easily visualized near the tip of the freer elevator.

Fig. 7. Excised neuroma.

the nerve was preserved in 23 cases with release of the deep transverse metatarsal ligament. Total relief of symptoms was appreciated in all but one from each group. Both were treated successfully, with resection in the neurolysis group and more proximal resection in the neurectomy group.

Decompression with relocation has also been described.[45] With this procedure, the deep transverse intermetatarsal ligament is transected and the nerve is relocated above the ligament. A 6-0 Prolene suture is placed longitudinally through the epineurium of the nerve and tied to the periosteum or deep fascia of the adjacent metatarsal above the ligament. In this study of 82 feet in 78 patients, 95% of patients achieved complete resolution of preoperative symptoms within an average of 7 days, with full sensation restored at an average of 5 weeks.[45]

Another type of surgical management of a Morton neuroma is cryogenic neuroablation, which is a minimally invasive procedure applied at a temperature of $-50^{\circ}C$ to $-70^{\circ}C$ to the nerve. This procedure results in demyelination and ensuing wallerian degeneration of the axon, leaving the epineurium and perineurium intact. Preservation of these structures prevents the formation of stump neuromas during nerve regeneration. The drawbacks of this procedure are that the results are not permanent and that the procedure is less effective on larger neuromas or in the presence of fibrosis.[24,46]

COMPLICATIONS

Surgical treatment of Morton neuroma is not without complications. The most reported and discussed complication is recurrent or stump neuroma, which may be caused by not resecting the nerve proximal enough, incomplete excision, or tethering of the nerve to the plantar aspect of the metatarsophalangeal joint or other structures.

Typically, revisional surgery is performed through a plantar approach. Several surgeons advocate implantation of the proximal end of the nerve into an intrinsic muscle in the arch of the foot.[40,42,47] Wolfort and Dellon[47] found an additional diagnosis of tarsal tunnel syndrome in 54% of the patients who had recurrent Morton neuroma. It is not known whether these pathologies coexisted preoperatively or whether a misdiagnosis occurred.

Another complication is the resection of the digital artery during neurectomy. Su and colleagues,[48] in a review of 674 consecutive pathologic specimens, found that the digital artery was identified with the resected nerve in 39% of specimens. The investigators found no adverse effect from concomitant excision of the vessel, and hypothesized extensive collateralization of the digital vessels as an explanation for the lack of adverse outcome. There was no difference in the frequency of arterial removal between dorsal and plantar approaches to nerve excision.

Postoperative hammertoe formation has been observed. This condition is thought to be caused by inadvertent resection of the lumbrical tendon during the surgical procedure. Other complications have been reported and include, but are not limited to, hematoma, infection, complex regional pain syndrome, and hypertrophic or keloid scar formation.

SUMMARY

Morton neuroma is a common source of forefoot pain. This condition is more correctly termed as interdigital nerve compression and is not a true neuroma. Although the diagnosis is mainly clinical, imaging options are available to aid in diagnosis. Nerve conduction velocity and electromyography should be considered in complex cases or in the case of multiple neuromas to rule out more proximal nerve pathology. Many studies have shown excellent results with conservative measures.[26,31,32] When conservative measures fail and symptoms persist, surgical intervention is necessary. Surgical options include excision, decompression, and cryogenic neuroablation. All treatments have their benefits, drawbacks, and complications, and at this point, the procedure selection is the surgeon's preference.

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