ANNALES ACADEMIAE MEDICAE SILESIENSIS

ACCEPTED MANUSCRIPT

Ann. Acad. Med. Siles. (Online) 2026; DOI: 10.18794/aams/217118

Review

Morton's neuroma: A systematic review of pathophysiology, diagnosis, and management

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Received: 13.11.2025, Revised: 11.01.2026, Accepted: 18.01.2026, Published: April 2026

Publisher: Medical University of Silesia, Katowice, Poland

ABSTRACT

Morton’s neuroma (MN) is a common neuropathy of the interdigital nerve, most often between the third and fourth metatarsal heads. Despite its common occurrence, approaches to diagnosis and treatment may differ. This review summarizes current evidence on the pathophysiology, diagnostic evaluation, and management of MN. We conducted a PubMed search up to October 2025, using the terms “Morton’s neuroma,” “interdigital neuralgia,” “forefoot pain,” and “nerve entrapment,” with a focus on clinical presentation, imaging, and treatment. Included studies were randomized controlled trials, cohort studies, and systematic reviews, while case reports, letters, non-English articles, and conference abstracts were excluded. Morton’s neuroma typically affects middle-aged women, and it's commonly related to mechanical compression, footwear, and foot biomechanics. Diagnosis is mainly clinical, with provocative tests, such as Mulder’s click, helping to identify the condition. Ultrasound is a first-line imaging tool, due to its high diagnostic accuracy and capacity for real-time guidance. Non-surgical therapies, such as footwear change, orthoses, and ultrasound-guided corticosteroid injections, can provide short-term symptom improvement, usually lasting up to 12 months. Approximately one-third of patients may require surgery. Surgical options, such as neurectomy, intermetatarsal ligament release, and dorsal nerve transposition, can provide long-term relief, but they carry risks of sensory loss, stump neuroma, and recurrence. Emerging minimally invasive techniques show potential but need further study. Management should be tailored to the severity of symptoms and their functional impact to achieve the best outcomes.

KEYWORDS

compressive neuropathy, dorsal nerve transposition, forefoot pain, interdigital neuralgia, interdigital neurectomy, Morton’s neuroma, ultrasound-guided corticosteroid injections

INTRODUCTION

Morton’s neuroma (MN) is a compressive neuropathy affecting the common plantar digital nerve. Its most frequent location is between the third and fourth metatarsal heads. The condition develops from chronic irritation and mechanical entrapment of the interdigital nerve beneath the deep transverse intermetatarsal ligament. This results in progressive neural degeneration. Histological findings typically reveal endoneurial edema, axonal degeneration with segmental demyelination, arterial degeneration, and dense perineural fibrosis, all of which may present as localized forefoot pain and altered sensation [1,2,3,4,5,6,7].

Epidemiological data show that MN mainly affects middle-aged women, with the indication that women are five times more likely to develop the condition than men [8]. This difference is attributed to biomechanical differences and external factors, especially the use of narrow or high-

heeled shoes, which increases plantar pressure across the metatarsal heads [8]. Although there is no precise data about incidence in the general population, MN is among the most common causes of forefoot pain encountered in orthopedic and primary care practice [8]. Population data from the United Kingdom estimates approximately 87.5 cases per 100,000 women and 50.2 per 100,000 men per year [9], making MN the third most common condition referred to foot and ankle surgeons in the UK [10]. Neuromas can be present in all four intermetatarsal spaces. However, the third interspace is by far the most frequently affected, from 42% to 86%, followed by the second interspace, ranging from 5% to 57% [11,12]. Typically, MN is present unilaterally; however, multiple neuromas developing within the same foot are relatively common, often located in adjacent intermetatarsal spaces. Bilateral cases are uncommon [13]. Radiological studies have shown that subclinical or asymptomatic neuromas may coexist within the same foot, suggesting that the actual prevalence of MN is likely underreported [8,13].

METHODS

This review was conducted by searching the PubMed database for literature on Morton's neuroma. The search included articles published up to October 2025, using the terms "Morton's neuroma," "interdigital neuroma," "forefoot pain," and "nerve entrapment", focusing on pathophysiology, imaging, epidemiology, clinical presentation, and management of MN. Both original research and review papers were considered, whereas non-English publications and conference abstracts were excluded.

REVIEW

Clinical presentation

Morton's neuroma (MN) typically presents with localized forefoot pain. That pain is often described by patients as a burning or stabbing feeling that spreads into the toes, most often on either side of the involved interspace [2,14]. The pain commonly appears during longer walks or when wearing tight shoes. Removing footwear or massaging the area usually brings quick relief [2,14]. Many patients describe a sensation of "walking on a pebble" or feeling fullness beneath the metatarsal heads. While this sensation is not unique to Morton's neuroma, it tends to prompt closer examination of the affected area [2,15,16]. Other symptoms include sensory changes, such as numbness, tingling, or paresthesia in the nearby toes, which is the result of compression and irritation of the interdigital nerve. As the condition advances, pain can become severe, significantly limiting walking and physical activity [2,14].

Diagnosis

Physical examination findings

Physical examination remains crucial to the diagnostic evaluation of MN. Palpation of the intermetatarsal spaces often reveals localized tenderness. Among provocative maneuvers, the Mulder test is particularly informative. The test is performed by compressing the metatarsal heads

while palpating the interspace, which produces a palpable or audible "click" and a sharp pain radiating to the toes. This sign is considered highly specific (specificity ≈ 0.96, $LR^+ \approx 13.1$) and, when positive, strongly supports the diagnosis [14,15]. Webspace tenderness test (thumb-index finger squeeze test) has shown high sensitivity (≈ 0.96, $LR^- \approx 0.04$), making it useful to rule out MN when negative [14,15].

Other frequently reported symptoms include burning forefoot pain (sensitivity 54–57%, specificity 48%) and the "pebble" sensation (sensitivity 43–53%, specificity 52%) [14,15,16]. Although none of these findings are individually diagnostic, the combination of pain pattern, site-specific tenderness, and positive provocative tests significantly increases diagnostic confidence [14].

Primary care physicians need to recognize that MN often coexists with other forefoot conditions, such as metatarsalgia, bursitis, or plantar plate injuries, which can complicate diagnosis and treatment. Clinicians should be especially alert with women aged 40–60 years who present with chronic plantar forefoot pain that does not respond to footwear modifications or orthotic use. Early detection enables non-surgical management and may help prevent chronic nerve damage.

Table 1 presents the diagnostic accuracy of subjective features and physical examination tests in patients with Morton's neuroma. Pitcher et al. [14] analyzed the diagnostic value of subjective features using likelihood ratios (LR). Patient-reported clicking was the strongest indicator, with an LR^+ of 13.14, providing strong evidence for Morton's neuroma. Other symptoms, including burning pain and "walking on a pebble", had LR^+ values below 2, offering limited diagnostic utility. Features such as pain in the second or third interspace, paresthesia, clicking, and pain from tight shoes showed LR^- between 0.2 and 0.5, giving modest evidence against MN when absent, while all other features had LR^- above 0.5, indicating low value for ruling out the condition.

Table 1. Diagnostic accuracy of subjective features and physical examination tests for Morton's neuroma

Symptom / Test	Sensitivity	Specificity	Positive LR	Negative LR
Subjective clicking (patient-reported)	—	0.96	13.14	—
Modified webspace tenderness (thumb–index squeeze test)	0.96	0.49	1.88	0.04
Mulder's click (palpable/audible)	0.61–0.94	0.62–0.97	2.1–12.0	0.09–0.63
Burning forefoot pain	0.54–0.57	0.48	1.04	0.92

Sensation of "walking on a pebble"	0.43–0.53	0.52	0.9–1.1	0.88
Pain aggravated by walking	0.91–0.92	0.37–0.55	1.45	0.16
Pain aggravated by footwear	0.75–0.86	0.42–0.60	1.4	0.25
Forefoot pain (any)	1.00	0.13	1.15	0.00
Dysesthesia / altered sensation	0.00	0.70–0.80	—	—

Table note: Data adapted from Pitcher et al. [14]. All values are presented as reported in the original systematic review. Data have been reformatted and paraphrased for clarity.

Radiological diagnosis

Imaging plays a crucial role in confirming the diagnosis of Morton's neuroma (MN) and distinguishing it from other causes of metatarsalgia. Radiological evaluation can help confirm the diagnosis, define the lesion's size and position, and provide valuable preoperative information. Ultrasound (US) and magnetic resonance imaging (MRI) are considered the most reliable and informative techniques [17,18,19].

Plain radiographs are typically not relevant in Morton's neuroma. In some cases, mild widening of the intermetatarsal space or splaying of adjacent toes (Sullivan's sign) may suggest a soft-tissue lesion, though these findings are nonspecific and not diagnostic [1,20].

Ultrasound (US) is a preferred imaging modality [11,21,22] due to its availability, low cost, absence of contraindications, and ability to correlate pain in real time [7]. On ultrasound, MN typically appears as a well-defined, hypoechoic, round or ovoid lesion within the intermetatarsal space just proximal to the metatarsal heads. The lesion is usually noncompressible, and in some cases, may demonstrate heterogeneous echotexture due to variable fibrosis and edema [7,19,20]. The examination can be performed from either a dorsal or plantar approach, though the dorsal sagittal view is often easier and more comfortable for the patient [23]. Each intermetatarsal space is systematically assessed, and gentle probe pressure may reproduce characteristic pain. Applying pressure with the probe may reproduce the patient's characteristic pain, known as the sonographic Mulder sign, which supports the clinical diagnosis [1,17,24].

MRI findings typically show a spindle- or dumbbell-shaped soft-tissue mass located in the intermetatarsal space. The lesion demonstrates low to intermediate signal intensity on T1-weighted images, low signal on T2-weighted sequences, and variable enhancement following gadolinium administration. MRI is particularly useful for evaluating surrounding soft-tissue structures and distinguishing Morton's neuroma from other causes of forefoot pain, such as intermetatarsal

bursitis, plantar plate injury, or capsular inflammation [25,26]. Table 2 presents a comparison of different radiological techniques in the diagnosis of MN.

Lesion size is an important radiological clue: symptomatic neuromas tend to measure over 5 mm in diameter, whereas smaller ones are often incidental or asymptomatic findings [25]. Integrating imaging data with clinical features remains crucial for accurate diagnosis and individualized management.

Table 2. Comparison of different radiological techniques in the diagnosis of MN [1]

Imaging modality	Typical findings	Diagnostic performance	Clinical advantages	Limitations
Plain radiography	Usually normal; may rarely show widening of intermetatarsal space or divergence of adjacent toes ("Sullivan's sign").	Non-specific; cannot directly visualize the lesion.	Excludes fractures, deformities, or degenerative changes that mimic MN.	Very low sensitivity and specificity for MN; not diagnostic.
Ultrasound	Ovoid or fusiform hypoechoic lesion within intermetatarsal space, contiguous with plantar digital nerve; may elicit a sonographic Mulder sign.	Sensitivity 85–95%; specificity 80–90% [17,18]	Inexpensive, widely available, dynamic correlation with pain, option for image-guided injection in the same session.	Operator-dependent; may overestimate lesion size when a bursal component is present.
Magnetic resonance imaging	Ovoid or dumbbell-shaped lesion plantar to the deep transverse metatarsal ligament; low-to-intermediate signal on T1 and T2; variable enhancement post-contrast.	Sensitivity 82–90%; specificity 88–90% [17,18]	Excellent soft-tissue contrast; useful for equivocal or complex cases and pre-surgical mapping.	High cost, limited availability; lesions may be inconspicuous on fat-suppressed sequences.

Clinical assessment protocol

A clearer diagnosis can be made with the assistance of a clinical assessment protocol (Delphi recommendations) for the diagnosis of forefoot neuroma presented in the study by Dando et al. [15]. Protocol consists of 21 recommendations divided into following themes: location of pain, non weight bearing sensation, weight bearing sensation, observations, tests and imaging [15].

Treatment

Figure 1 presents a practical summary of the diagnosis and management pathway for patients diagnosed with Morton's neuroma.

Non-surgical treatment

First-line treatment begins with conservative measures (shoe modifications, orthoses, activity modifications) and may progress to image-guided injections if symptoms persist. A systematic

review of non-surgical therapies concluded that corticosteroid injections produce statistically significant short-term pain reduction and about a 50% success rate at 12 months in pooled series [27,28,29,30,31], while other methods, including alcohol injections [32,33,34,35,36,37,38], radiofrequency ablation (RFA) [39,40], cryoablation [41], extracorporeal shock wave therapy (ESWT) [42,43], capsaicin [44], botulinum toxin [45], orthoses [46], YAG laser therapy [47], show variable but sometimes clinically meaningful benefit; however, the quality and comparability of studies are limited and larger randomized trials are needed [48].

Corticosteroid injections

Corticosteroid injection, often combined with a local anesthetic (CS + LA), remains one of the most commonly used nonsurgical options for Morton's neuroma. Evidence from a recent Cochrane review indicates that CS + LA provides little or no difference in pain or functional outcomes compared with local anesthetic alone at 3–6 months [49]. Adverse effects are rare and usually mild, such as temporary skin atrophy or plantar fat-pad thinning [49].

A systematic review of 5 studies (3 randomized clinical trials, 1 comparative, 1 cohort) found that corticosteroid injections led to a modest reduction in pain scores, from a mean VAS of 6.6 to 4.3, after approximately 11 months of follow-up [27,28,29,48]. Symptomatic improvement and functional gains were generally greater in neuromas smaller than 5 mm on ultrasound [31]. Sustained improvement up to 12 months has been observed in most studies. Still, approximately half of patients experience symptom recurrence beyond one year, and around one-third ultimately undergo surgical excision for persistent pain [48]. Adverse effects such as mild skin atrophy or hypopigmentation are uncommon.

Randomized trials report better outcomes at six months when corticosteroid injections are performed under ultrasound guidance rather than blindly, clinically important additional pain reduction (≈ −15 mm on a 0–100 VAS), improved functional scores (SMD ≈ −0.47) and higher patient satisfaction (RR ≈ 1.7), with no clear increase in adverse events [31,50]. This supports the use of ultrasound for targeting corticosteroid injections.

Overall, corticosteroid therapy offers a safe, moderately effective option for short-term management, particularly in small lesions, but long-term durability remains limited, highlighting the need for extended follow-up [48].

Surgical treatment

Surgery is typically reserved for patients with persistent symptoms despite adequate conservative therapy. The standard procedure - interdigital neurectomy - provides reliable pain relief for many patients but is associated with a considerable risk of permanent digital numbness, stump neuroma formation, and residual neuropathic pain. As a result, nerve-preserving or decompressive techniques have gained attention as potential alternatives [51].

Isolated release of the deep transverse intermetatarsal ligament (DTIML) has shown promising results in small clinical series. In one study of 12 patients followed for a mean of 13.5 months, pain scores (VAS) decreased from 6.4 to 2.0, with no reported cases of stump neuroma or permanent numbness [52].

Neurolysis and decompression of the interdigital nerve through a dorsal approach (Dellon technique) have demonstrated significant improvements in pain and function, with low complication rates and preservation of cutaneous sensation in most patients, supporting this as a technically simple, nerve-sparing option [53].

Dorsal nerve transposition or dorsal neurolysis—relocating the nerve to a tension-free position—has been associated with favorable long-term outcomes. In a large retrospective series, 64% of patients reported complete pain relief, though sensory deficits occurred in approximately two-thirds of cases, and 19% expressed postoperative regret, underscoring the balance between pain reduction and sensory loss [54]

A systematic review comparing operative techniques other than neurectomy found lower rates of postoperative neurogenic symptoms following neurolysis than after nerve excision. The review suggested that combining neurolysis with dorsal transposition may optimize outcomes while minimizing complications. However, the quality of evidence remains variable, and minimally invasive procedures such as percutaneous DTIML release show inconclusive long-term efficacy. When neurectomy is performed, burying or transposing the nerve stump is recommended to reduce the risk of recurrent neuroma formation [51].

Outcomes and recurrence

Surgical management of Morton's neuroma provides substantial symptom relief in most patients, with reported success rates of 70–85%. However, 15–30% experience persistent or recurrent pain due to stump neuroma, scar entrapment, or incomplete excision, and up to 20% may require revision surgery [52,53].

Dorsal surgical approaches are typically linked to faster recovery and fewer wound complications, while plantar access may reduce recurrence risk in select patients [53]. Nerve-sparing methods, including decompression and dorsal transposition, have shown durable pain relief with lower neurogenic complication rates—in one long-term series, 64% of patients reported complete pain resolution, although sensory loss remained common [54].

Recurrence risk increases with larger neuromas, longer symptom duration, or prior interventions. Techniques embedding or transposing the nerve stump may help reduce painful recurrence [51]. Overall, surgery remains effective for refractory cases, but patients should be counselled about possible sensory loss and recurrence risk.

Step 1: Clinical Assessment

- Evaluate forefoot pain and perform Mulder's squeeze test.

- Identify symptoms typical of Morton's neuroma (burning pain, tingling between toes, relief after shoe removal).

Step 2: Imaging

- **First-line:** Ultrasound for diagnosis and dynamic assessment.
- **Second-line:** MRI if ultrasound is inconclusive or to assess differential diagnoses (bursitis, plantar plate tear).

Step 3: Conservative Management

- Modify footwear (wide toe box, low heel).
- Use metatarsal pads or custom orthoses.
- Consider pharmacologic pain management or physiotherapy.

Step 4: Minimally Invasive Options

- Ultrasound-guided corticosteroid or alcohol injection (temporary relief possible).
- Consider radiofrequency ablation (RFA), cryoablation, or extracorporeal shockwave therapy (ESWT) if conservative care fails.

Step 5: Surgical Intervention

- Reserved for persistent cases (>6–12 months).
- Choose between neurectomy, decompression (DTIML release), or nerve transposition depending on neuroma size and chronicity.
- Postoperative follow-up for recurrence or sensory disturbance.

Fig. 1. Practical summary of the diagnostic pathway

CONCLUSIONS

Morton's neuroma remains a frequent cause of forefoot pain, and its evaluation relies mainly on a thoughtful clinical assessment. Diagnosis should rely on careful clinical assessment supported by ultrasound imaging, which improves both accuracy and treatment precision. Conservative management, including footwear modification, orthoses, and ultrasound-guided corticosteroid injections, should be prioritized as first-line therapy. Surgical or minimally invasive interventions, such as neurectomy, decompression, or radiofrequency ablation, are reserved for cases unresponsive to non-surgical care. A stepwise, evidence-based approach and further high-quality studies are needed to optimize long-term outcomes and guide standardized management for patients with Morton's neuroma.

Use of AI tools statement

Grammarly was used solely for language editing to improve clarity and fluency; it did not influence the scientific content of the manuscript.

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