

Diagnostic Accuracy of Clinical Tests for Morton's Neuroma Compared With Ultrasonography



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ARTICLE INFO

Level of Clinical Evidence: 3

Keywords:

clinical test
diagnosis
interdigital neuroma
ultrasound

ABSTRACT

The aim of the present study was to assess the diagnostic accuracy of 7 clinical tests for Morton's neuroma (MN) compared with ultrasonography (US). Forty patients (54 feet) were diagnosed with MN using pre-determined clinical criteria. These patients were subsequently referred for US, which was performed by a single, experienced musculoskeletal radiologist. The clinical test results were compared against the US findings. MN was confirmed on US at the site of clinical diagnosis in 53 feet (98%). The operational characteristics of the clinical tests performed were as follows: thumb index finger squeeze (96% sensitivity, 96% accuracy), Mulder's click (61% sensitivity, 62% accuracy), foot squeeze (41% sensitivity, 41% accuracy), plantar percussion (37% sensitivity, 36% accuracy), dorsal percussion (33% sensitivity, 26% accuracy), and light touch and pin prick (26% sensitivity, 25% accuracy). No correlation was found between the size of MN on US and the positive clinical tests, except for Mulder's click. The size of MN was significantly larger in patients with a positive Mulder's click (10.9 versus 8.5 mm, $p = .016$). The clinical assessment was comparable to US in diagnosing MN. The thumb index finger squeeze test was the most sensitive screening test for the clinical diagnosis of MN.

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Morton's neuroma (MN) is an entrapment degenerative neuropathy. Patients with MN typically present with symptoms of forefoot pain, which can be associated with abnormal sensations, such as burning, tingling, or numbness (1). Some will complain of fullness under the toes or the feeling of a "pebble in the shoe" and that shoe wear tends to aggravate symptoms (2).

The pathogenesis of the condition remains a point of contention, but ischemia and mechanical compression of the plantar nerve have been identified as possible causes (2,3). The end result of these insults is a thickened nerve with histologic findings of perineural fibrosis (4–6).

The diagnosis of MN is typically made clinically, although in equivocal cases, ultrasonography (US) (7,8), magnetic resonance imaging (9,10), or injection of local anesthetic (11) can be used. Not only can imaging techniques confirm the diagnosis, but they can also exclude other pathologic entities such as synovitis or arthritis. Numerous clinical tests for MN have been described in published

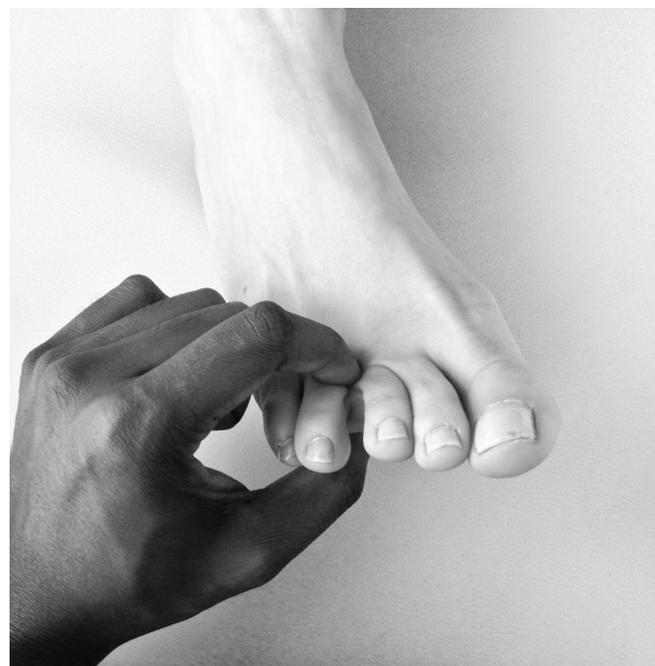


Fig. 1. View of thumb index finger squeeze test.

Financial Disclosure: None reported.

Conflict of Interest: None reported.

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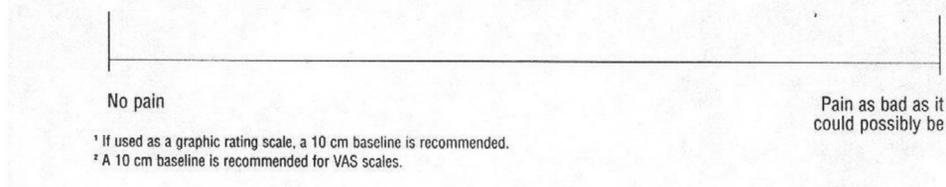
Clinical features of Morton’s neuroma

Patient details:

Date: / /

Symptoms	Tick positives
Side	Right <input type="checkbox"/> Left <input type="checkbox"/> Both <input type="checkbox"/>
Length of symptoms months / years
History of trauma	Yes <input type="checkbox"/> No <input type="checkbox"/> Specify:
Pain	Yes <input type="checkbox"/> No <input type="checkbox"/>
Character of pain	Burning <input type="checkbox"/> Ache <input type="checkbox"/> Cramp <input type="checkbox"/> Pain at rest <input type="checkbox"/> Pain at night <input type="checkbox"/> Pebble in shoe <input type="checkbox"/>
Altered sensation to toes	Yes <input type="checkbox"/> No <input type="checkbox"/>
Aggravating factors	Shoe wear <input type="checkbox"/> Walking <input type="checkbox"/>
Relieving factors	Rest <input type="checkbox"/> Removing shoe <input type="checkbox"/> Massaging <input type="checkbox"/>

c. Visual Analog Scale (VAS)²



Clinical signs	Tick positives
Mulder’s click	Yes <input type="checkbox"/> No <input type="checkbox"/>
Thumb index finger squeeze	Yes <input type="checkbox"/> No <input type="checkbox"/>
Foot squeeze	Yes <input type="checkbox"/> No <input type="checkbox"/>
Dorsal percussion	Yes <input type="checkbox"/> No <input type="checkbox"/>
Plantar percussion	Yes <input type="checkbox"/> No <input type="checkbox"/>
Abnormal light touch	Yes <input type="checkbox"/> No <input type="checkbox"/>
Abnormal pin prick	Yes <input type="checkbox"/> No <input type="checkbox"/>
Involved intermetatarsal space	IM 1 <input type="checkbox"/> IM2 <input type="checkbox"/> IM 3 <input type="checkbox"/> IM 4 <input type="checkbox"/>

Fig. 2. Questionnaire for patients with Morton’s neuroma.

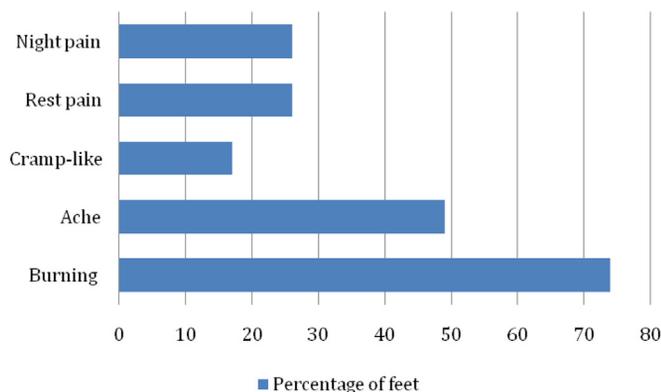


Fig. 3. Descriptions of pain in feet with Morton's neuroma confirmed by ultrasonography.

data; however, their reported sensitivity values have varied enormously and the most consistent clinical test is yet to be reported (12).

Patients and Methods

The aim of the present study was to compare the ability of various clinical tests to detect MN at the site of symptoms against the use of US.

The patients were recruited in a tertiary foot and ankle clinic from June 2012 to April 2013. Patients presenting with forefoot pain were clinically evaluated by the senior author (M.B.). The clinical criteria used by the senior author (M.B.) to diagnose MN were localized forefoot pain with ≥ 1 positive clinical tests at the site of the symptoms. The following tests were evaluated:

1. **Thumb index finger squeeze test** (Fig. 1): The symptomatic intermetatarsal space is squeezed between the tips of the index finger (dorsal) and thumb (plantar). Splaying of the involved toes was used as a guide for correct positioning and pressure of the thumb and index finger. The test was considered positive if pain was produced (modified from the "web space tenderness" test [13]).
2. **Mulder's click** (14): The foot is clasped around the metatarsal heads with the fingers of 1 hand, and the thumb of the contralateral hand exerts firm pressure on the sole of the foot at the site of the MN. Firm lateral compression of the metatarsal heads is then applied with the fingers. The test was considered positive if a palpable click was felt.
3. **Foot squeeze test** (13): The foot is clasped with the fingers, and the metatarsal heads are squeezed together. The test was considered positive if localized pain was produced at the intermetatarsal space in question.
4. **Plantar and dorsal percussion tests** (13): The dorsal and plantar intermetatarsal spaces were percussed with a finger. The test was considered positive, if localized pain was present at the intermetatarsal space with percussion.
5. **Light touch sensory test**: The toe tip is stroked with a finger. The test was considered positive if the subjective sensation was different from that on the adjacent toes.
6. **Pin prick sensory test**: A Neurotip™ (Owen Mumford Ltd., Oxford, UK) is applied to the toe tip. The test was considered positive if the subjective sensation was different from that on the adjacent toes.

We excluded patients with peripheral neuropathy, significant hallux valgus and/or deformity of the lesser toes, metatarsophalangeal joint subluxation or instability, previous forefoot surgery, and inflammatory arthropathy.

All consecutive patients who had positive clinical test results for MN and who fulfilled these criteria constituted our study cohort. They were referred for US

confirmation of MN. A questionnaire designed to identify the characteristics of the condition, including a visual analog scale for pain, was also completed (Fig. 2). The US scans were performed by a single experienced musculoskeletal radiologist (R.B.). All 4 intermetatarsal spaces of the symptomatic foot were screened. An US diagnosis of MN was made when a focal, noncompressible hypoechoic nodule was visualized in the normally hyperechoic interdigital fat of the web spaces at the level of the metatarsal heads. The size and site of the MN lesions were recorded. For the purpose of the present study, US was set as the reference standard for the diagnosis of MN and the diagnostic ability of clinical tests were compared to it.

When a MN was detected using US at the site of the symptoms, an injection of methylprednisolone acetate 40 mg/mL in 1 mL of 0.5% bupivacaine was also given as a therapeutic measure. The immediate response to the injection was recorded.

The tabulation and analyses of the clinical tests and US findings were performed by 2 independent clinicians (D.M. and M.V.). The data were analyzed using IBM SPSS Statistics software, version 19 (IBM, Armonk, NY). The Pearson correlation coefficient was used to assess correlation between the visual analog scale and the size of MN. Associations between the size of MN and clinical tests were assessed using the Mann-Whitney *U* test. Significance was determined at $p \leq .05$.

Results

A total of 54 feet in 40 patients were clinically suspected of having MN. The mean age at diagnosis was 54 (range 26 to 74) years, with a female preponderance ($n = 31$ [79%]). Six patients (6 feet [11%]) had diabetes, but none had neuropathy. The duration of symptoms varied from 2 months to 10 (mean 2.3 ± 2.0) years in the affected feet. The right foot was affected in 14 patients (35%), the left foot in 12 (30%), and both feet in 14 (35%).

MN was detected using US at the site of clinical diagnosis in all but 1 foot in our series (98%). The patient was diagnosed with metatarsophalangeal joint synovitis. Only the foot squeeze test was positive in that patient. MN was detected in the second web space in 20 feet (38%), the third web space in 18 feet (34%), and in the concomitant ipsilateral second and third web spaces in 15 feet (28%). We also found asymptomatic ipsilateral MN (size 8 to 10 mm) in 3 feet (5%). The average transverse diameter of symptomatic MN using US was 9.4 (range 5 to 15) mm, and MN was not detected in the first and fourth web spaces.

The pain characteristics of the patients with MN are shown in Fig. 3. Altered sensation was described in 32 feet (60%), and the sensation of "like having a pebble in the shoe" was reported in 28 feet (53%). In 9 feet (17%), trauma was described as the trigger for the onset of symptoms. Shoe wear and walking exacerbated symptoms in 40 (75%) and 49 (92%) feet, respectively. The symptoms were relieved by removing the shoes in 30 feet (57%), massaging in 15 (28%), and resting in 44 (83%). The average pain recorded on the visual analog scale was 6.6 (range 0 to 10).

The most sensitive clinical test for MN in the present series was the thumb index finger squeeze test, which was positive in 96% of the feet with MN confirmed by US (sensitivity 96%, specificity 100%, accuracy 96%). This was followed by Mulder's click and the foot squeeze test (Table). The least sensitive tests were the sensory tests and dorsal and plantar percussion tests. All the clinical tests investigated had high positive predictive values (95% to 100%) but very low negative predictive values ($\leq 33\%$). The operational characteristics of the

Table
Operational characteristics of diagnostic clinical tests compared with ultrasonography

Test	Positive Clinical Tests	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy Rate (%)
Thumb index finger squeeze	51 (96)	96	100	100	33	96
Mulder's click	34 (64)	62	100	100	0	61
Foot squeeze	23 (43)	41	0	95	0	41
Plantar percussion	19 (36)	36	100	100	3	37
Dorsal percussion	17 (32)	26	100	100	3	33
Abnormal light touch	13 (25)	25	100	100	2	26
Abnormal pin prick	13 (25)	25	100	100	2	26

Data presented as n (%), unless otherwise noted.

diagnostic clinical tests performed compared with the reference standard US diagnosis of MN are listed in Table.

The size of MN was significantly larger in patients with a positive Mulder's click (10.9 ± 1.2 mm versus 8.5 ± 1.1 mm, $p = .016$, Mann-Whitney U test). No association was found between pain severity (visual analog scale) and the size of MN using US (Pearson's correlation coefficient $r = -0.271$, $p = .148$).

All patients with an US diagnosis of MN had immediate pain relief from the methylprednisolone and bupivacaine injection. Surgery was offered when the symptoms recurred after injection therapy. At the last follow-up point, 16 feet (30%) had been surgically treated for symptom recurrence, and histologic examination confirmed the diagnosis in all 16. The remaining patients have been followed up to monitor the natural course of MN.

Discussion

US detected MN in all the sites that were clinically positive, except for in 1 foot. Our study has shown that the clinical assessment is highly reliable at detecting symptomatic MN.

The demographics of our study population were similar to those described in published reports (12,15–17). Almost 80% of our patients with MN were females compared with the reported prevalence, which is ≤ 5 times greater in females (12,15,16). The mean age at presentation was 54 years, also similar to the published data (12,15,17).

Investigators have reported a predilection of MN for the third web space (2,13,18,19) and have postulated the anatomic reasons for this. First, the interdigital nerve in the third web space is potentially thicker, because it is usually formed by the confluence of the terminal branches of the medial and lateral plantar nerves (20). Second, the third web space might have larger shearing forces owing to the relative mobility of the fourth metatarsal compared with the relatively fixed third metatarsal (1). In the present study, however, the distribution of MN in the second and third web spaces was almost equal; a finding noted by other investigators (15,21,22). Our results are supported by observations that the second and third interspaces were significantly narrower than the adjacent spaces (23). The prevalence of MN in the first and fourth interspaces has been very rare (1,16,24), and we detected none using US. Trauma can result in the formation of MN (1), and this was observed in 17% of our studied feet.

Symptomatic concomitant ipsilateral and bilateral MNs are not that rare and can occur in $\leq 3\%$ and 15%, respectively (1,25). In our series, the prevalence was much greater, with 35% of patients having bilateral symptomatic MN and 28% of feet having concomitant ipsilateral symptomatic MN. Nevertheless, one should be aware of the prevalence of asymptomatic MN in the population. A study found that 54% of patients with unrelated mid- and hindfoot pathologic features but asymptomatic forefeet had an US detected MN (22). Another study detected asymptomatic MN on magnetic resonance imaging in 33% of 57 asymptomatic feet (26). We had a 5% occurrence of asymptomatic ipsilateral MN. Correlation with the clinical examination findings is crucial to avoid unnecessary treatment.

We found no association between the intensity of pain and the size of MN. Studies have shown that lesions >5 mm are more likely to cause symptoms (8,27). In our study, the size of symptomatic MN using US ranged from 5 to 15 mm. However, the 3 asymptomatic MNs detected were all >8 mm.

The most consistent presenting symptom was forefoot pain, which was associated with a burning sensation in 74% of the feet. Forefoot ache was reported by just less than one half, and one quarter of feet had pain at rest or at night. Just as we observed, pain at night or at rest is not such an uncommon feature. One study reported an incidence of pain at rest of 10% and at night of 19% (28). Although pain is induced

by nerve compression or ischemia (2,3), only 60% of feet presented with altered sensation or numbness in our series.

Shoe wear worsened the symptoms in 75% of our feet, an observation matched by others, with symptoms ranging from 70% to 76% (29,30). One feature of MN is that a patient might gain moderate relief by resting after walking, removing the shoe, and massaging the area of discomfort (2,31). We found that resting alleviated symptoms in $>80\%$ and shoe wear removal helped in 50%; however, only one quarter of patients had some relief from massaging.

The significance of Mulder's click, which was considered pathognomonic of MN, has been debated, because the prevalence of a positive Mulder's click has ranged from 27% to 84% in published studies (14,29,30). In our series, only 64% of feet with MN had a positive Mulder's click (sensitivity 62%), and it was only present when larger lesions were examined. In contrast, the thumb index finger squeeze test (Fig. 1) was positive in 96% of the feet with an US diagnosis of MN, irrespective of size.

We found the other clinical tests were less reliable in detecting MN. The foot squeeze, dorsal and plantar percussion, and pin-prick and light-touch sensory tests had individual test sensitivities of $<50\%$. All these tests, however, were highly specific for MN, except for the foot squeeze test.

US was set as the reference standard for the diagnosis of MN in our study. US is widely used in U.K. centers and generally has good specificity and sensitivity (65% to 98%) (8,27,32). The other advantage of US is the potential for the operator to administer treatment (injection under image guidance) within the same setting. US is, however, user dependent, and we, therefore, used a single, experienced radiologist to minimize this effect. Dynamic US was also used in all cases, and this approach has been shown to increase US sensitivity (33).

The present study had some limitations. We acknowledge that the diagnosis of MN had not been confirmed by histologic examination in all our patients, which some might consider the reference standard. Obtaining histologic diagnoses for all patients was not possible, because only some patients (30%) required surgery for symptom recurrence. However, the histologic examination confirmed the diagnosis in all the patients who had undergone surgery. Second, the questionnaire that was designed for our study was not tested for reliability or validity. However, it was mainly used for data collection and was designed using the characteristics reported in published studies.

In conclusion, we have shown that clinical assessment is comparable to US for the diagnosis of MN. In our experience, a positive thumb index finger squeeze test (Fig. 1) was the most sensitive and specific clinical test.

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