

Prevalence of Interdigital Nerve Enlargements in an Asymptomatic Population

Panagiotis D. Symeonidis, MD, PhD; Lukas D. Iselin, MD, PhD; Neil Simmons, MD, MBBS; Shaun Fowler, MD, MBBS;
George Dracopoulos, MBBS, FRACS; Peter Stavrou, MD, FRACS
Adelaide, Australia

ABSTRACT

Background: Morton's neuroma is a common primary diagnosis for referral to foot and ankle surgeons. On presentation, many patients have had an ultrasound reporting the presence of Morton's neuroma, which may not correlate with the clinical examination findings. The prevalence of such sonographic findings in the general population remains unknown. **Methods:** In this observational prospective study, patients with asymptomatic forefeet who were seen by two foot and ankle surgeons for unrelated mid- or hind foot pathology were examined clinically and sonographically for the presence of interdigital nerve thickening. Forty-eight volunteers participated in the study (96 feet). For the purpose of this study, asymptomatic thickenings greater than 5 mm in diameter were termed sonographic neuromas. Ultrasound examination was performed by two specialist musculoskeletal radiologists. **Results:** Fifty-four percent of the volunteers (26 of 48) had sonographic nerve thickening and in 17 cases (35.4%) enlarged nerves were found bilaterally. Differences for gender, original diagnosis or side of original pathology were not significant. Older subjects were more likely to have a sonographic neuroma ($p = 0.018$). Feet with a positive Mulder's click were more likely to have a sonographic neuroma ($p = 0.015$). **Conclusion:** Ultrasound, even in highly skilled hands, has a high rate of incidental finding of an asymptomatic interdigital nerve enlargement, which can lead to a false diagnosis of a Morton's neuroma. Sonographic evidence of Morton's neuroma per se is unreliable unless it is correlated with an equivocal clinical examination. Clinical examination

is still the gold standard for the diagnosis of a Morton's neuroma.

Level of Evidence: IV, Retrospective Case Series

Key Words: Morton; Ultrasound; Interdigital; Neuroma; Prevalence; Ultrasonography

INTRODUCTION

Since its first description in 1876 by Morton, the painful lesion, which bears his name and is also known as interdigital neuroma has sparked considerable debate, research and controversy.¹⁴ Betts in 1940 suggested stretching rather than compression as the cause of pain and introduced the term: "neuritis of the interdigital nerve."² Others also showed that the term "neuroma" is probably a misnomer, and neuritis is a more appropriate term to describe the condition.^{5,10,21} Still, the terms "Morton's" and "interdigital neuroma" and "neuritis" are being used interchangeably in the literature.

Metatarsalgia caused by an interdigital neuroma is one of the commonest presenting symptoms in primary health care. It is estimated that 50.2 men and 87.5 women per 100,000 new presentations in primary health care suffer from the condition.¹¹ Three percent of them will receive operative treatment.

Although a thorough clinical assessment remains the most sensitive and specific modality for the diagnosis of an interdigital neuroma,²⁰ ultrasonography (US) is often used for confirming the diagnosis. In experienced hands, its accuracy has been found to be comparable to magnetic resonance imaging (MRI) studies,^{9,12} with the advantages that US is portable, faster and less expensive than an MRI.²² A thickening of the interdigital nerve with a transverse diameter greater than 5 mm reliably confirms the diagnosis of a symptomatic Morton's neuroma.^{18,20,22,28}

The prevalence of interdigital neuromas in the general population is not known.²⁴ Moreover, the frequency of sonographic false-positive results, i.e., the incidental US imaging diagnosis of a thickening of the interdigital nerve with no

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article. Part of this work has been presented at the 25th AOFAS Summer Meeting in Vancouver, Canada, under the title: "Prevalence of Morton's neuroma on ultrasound in an asymptomatic population". The abstract was included in the Proceedings booklet of the meeting.

Corresponding Author:
Panagiotis Symeonidis, MD, PhD
E. Amynis 18, TK 54646
Thessaloniki
Greece
E-mail: p.symeonidis@gmail.com

For information on pricings and availability of reprints, e-mail reprints@datatrace.com or call 410-494-4994, x232.

clinical findings has not been clarified yet. In the presence of an equivocal clinical presentation of metatarsalgia, such a sonographic finding may affect the decision-making process leading to an unnecessary operation. The surgical treatment of Morton's neuroma has a failure rate of up to 35% according to some reviews.^{15,23} Some of these failures can be attributed to incorrect indication for surgery, such as the excision of an asymptomatic interdigital nerve.²⁶

We studied the prevalence of asymptomatic interdigital nerve thickenings in a patient population suffering from unrelated mid-, hindfoot, or ankle pathology. For the purposes of the study, these abnormal enlargements were termed sonographic neuromas because of their asymptomatic nature and lack of pathology specimen confirmation. We questioned whether independent parameters such as gender and age of the patients and the presence, type and region of another foot and ankle pathology were related to the incidence of these asymptomatic neuromas.

MATERIALS AND METHODS

Approval for the study was gained by the Institutional Review Board. Two orthopaedic foot and ankle specialists and two musculoskeletal radiologists were enrolled to the study. Patients recruited for the study were suffering from unrelated mid-, hindfoot, or ankle pathology, for which they would undergo US studies. The US was either for diagnosis, ultrasound-guided injection, or both. All patients were consented to undergo an additional diagnostic forefoot US in both their symptomatic and the contralateral foot. In patients with bilateral symptoms, both feet were examined. The site of the patient's symptoms and their primary pathology were documented. A thorough forefoot clinical examination of all feet was undertaken, including the documentation of the presence of a Mulder's click in any of the web spaces. Testing for the Mulder's click was performed by side to side compression of the involved metatarsal heads with one hand while at the same time alternating thumb and index finger pressure between the involved metatarsal heads with the other hand and feeling for a palpable click.¹⁴ The sonographers were blinded to the surgeon's findings. All web spaces were examined with the US and the size and location of any incidental sonographic neuromas recorded.

Forty-eight patients participated in the study (Table 1). Both feet were examined in each patient, a total of 96 feet. There were 25 men and 23 women, with a mean age of 47 (range, 17 to 71) years. Their primary clinical diagnosis, confirmed by the subsequent US was mainly synovitis or osteoarthritis of the ankle and subtalar joints respectively. In four patients symptoms were bilateral. Therefore, there were 52 symptomatic and 44 asymptomatic feet in the study group. The regions of the primary pathology were grouped accordingly to the ankle, subtalar and midfoot regions, with the tendons forming a separate group (Table 1).

Two musculoskeletal radiologists carried out the ultrasound scans using 15 Mz linear array transducers (Siemens' Sequoia, Mountain View, CA). The transducer was placed on the plantar aspect of the foot along the line of the first metatarsophalangeal joint. The transducer was then slowly moved laterally across the intermetatarsal spaces. The index finger of the non-scanning hand was used to indent the dorsal aspect of each space, pressing the neurovascular structures towards the probe. By angling the transducer each neurovascular bundle was identified with visible pulsations from the interdigital artery. If an area of suspicion was encountered the pressure from the dorsal aspect was removed allowing any potential bursal fluid to reaccumulate and then the pressure was re-applied. In this way bursae were squashed flat, implying that any remaining abnormality was an enlarged interdigital nerve. The enlargement had to involve the neurovascular bundle. Any oval thickening of the interdigital nerves of greater than 5 mm diameter was recorded. If a sonographic neuroma was encountered the transducer was placed transversely across the metatarsal head/MTPJ space region and the metatarsal heads were squeezed together with the non-scanning hand. On several occasions a typical Mulder's click was felt and observed as the neuroma popped onto the plantar aspect of the intermetatarsal space. No such click was ever encountered with swollen intermetatarsal bursae. Each intermetatarsal space was scanned in the same way. Occasionally the same region was scanned from the dorsal aspect for confirmation but in most cases this was not necessary.

Data was analyzed using the Fisher's exact test in addition to the t-test, after verifying the assumption of normality ($p = 0.341$). Descriptive results are given as mean (\pm SD) for the continuous variables and as frequencies for the discrete ones. The significance level was set at 5%. The analysis was conducted by the statistical package SPSS v.16.0.

RESULTS

Neither the type nor the region of the primary pathology of the symptomatic feet was related with the detection of an interdigital nerve enlargement. Sixty-two asymptomatic nerve thickenings were detected in total in 26 of the 48 patients (54.2%). In 17 patients (35.4%), enlarged nerves were found bilaterally. Patients with sonographic neuromas were older on average by more than 10 years than those with no neuromas detected ($p = 0.018$).

From the 96 studied feet, enlarged nerves were found in 46 feet (47.9%) (Table 2). In 16 cases, two enlarged nerves were found in adjacent web spaces of the same foot leading to a total of 62 sonographic neuromas. The presence of a primary symptom was not related to the detection of an enlarged nerve ($p = 0.105$). The diameter of the detected thickenings ranged from 5.1 to 10.5 (mean, 7.5) mm.

Thirty-three of the 62 were found in the third web space (53%), the remaining 29 found in the second web space. No

Table 1: Patient Demographics and Statistical Analysis

	Presence of sonographic neuroma			<i>p</i> Value
	Yes	No	Total	
Number of patients	26	22	48	
Male / Female	12/14	13/9	25/23	0.401*
Age: mean (std deviation)	51.23 (± 14.741)	40.92 (± 14.271)	47.74 (± 15.669)	0.018**
Bilateral symptoms	4	0	4	0.114*
Primary pathology (patients):				0.139*
Synovitis	8	13	21	
Osteoarthritis	9	4	13	
Other	9	5	14	
Total	26	22	48	
Region of primary pathology[±] (symptomatic feet):				0.415*
Ankle	8	12	20	
Subtalar	4	1	5	
Midfoot	8	4	12	
Tendons	8	6	14	
Other	2	1	3	
Total	30	24	54 [±]	

*, Fisher's exact test.

**, T-test.

[±], Two patients had two symptomatic regions per foot.**Table 2:** Foot Demographics and Statistical Analysis

	Presence of sonographic neuroma/s		Total	<i>p</i> Value
	Yes	No		
Number of feet	46	50	96	
Side (Right / Left)	22 right / 24 left	26 right / 24 left	48/48	0.838*
Foot symptomatic in other area	29	23	52	0.105*
Positive Mulder's click	13	4	17	0.015*
	2nd web space	3rd web space	Total	
Location of sonographic neuromas (%)	29 (48%)	33 (52%)	62 [§]	

*, Fisher's exact test.

[§], In 16 feet there were two neuromas detected per foot.

enlarged interdigital nerves were identified in the first and fourth web spaces.

All 96 feet were clinically tested for the presence of a Mulder's click (Table 2). The test was positive in 17 feet (17.7%). In 13 of these cases, a sonographic neuroma was detected. Therefore, 28% of the 46 feet with sonographic neuromas had a positive Mulder's click. On the other hand, only in four cases was there a Mulder's click in the absence of a neuroma. This clinical finding was related to

the detection of a nerve enlargement in the respective foot ($p = 0.015$).

DISCUSSION

Interdigital neuromas are one of the commonest causes of forefoot pain. However, considerable controversy still exists with regards to their aetiology and pathogenesis.⁶ Moreover, the prevalence of asymptomatic neuromas in the general

population remains largely unknown.²⁴ Clinical assessment remains the mainstay of the diagnosis of a Morton's neuroma. Typically, there is tenderness on palpation of the involved area, with reproduction of pain and paresthesias with direct plantar pressure between the metatarsal heads. A compression test consists of squeezing all the metatarsal heads together between the index and thumb and holding the position, in which case pain is elicited over the involved intermetatarsal space. Often the pain radiates distally to the toes along the course of the nerve with associated numbness. However, it has been shown that no solitary clinical feature would be adequate in confirming the diagnosis.²⁰ Imaging studies such as MRI and US are often used for this purpose, especially in atypical clinical presentations.

A recent review outlines US as the diagnostic modality of choice when used by experienced radiologists.⁶ Typically, neuromas appear as oval, hypoechoic masses oriented parallel to the long axes of the metatarsals.²⁶ The sensitivity of US in diagnosing interdigital neuromas has been reported to be between 94 and 100%.^{6,18,19} Forefoot US is often prescribed by referring physicians for forefoot pain before the patient consults a orthopaedic surgeon. In equivocal cases, the US finding of an interdigital neuroma may mislead the clinician. An awareness of the frequency of false positive findings can improve the clinical judgment resulting in fewer unnecessary therapeutic interventions.

We studied the incidence of asymptomatic interdigital nerve enlargements suggestive of neuromas in a patient population suffering from unrelated mid- or hindfoot pathology. In a previous study, Redd et al.¹⁸ showed that interdigital neuromas can be found in asymptomatic web spaces as well and only neuromas greater than 5 mm in diameter were causing symptoms. Others²⁰ have noted even smaller nerve enlargements to be symptomatic enough to warrant excision. Admittedly, diagnosing any enlarged nerve as a neuroma without histological confirmation is a compromise. Moreover, the actual histological term "neuroma" for these enlargements probably is a misnomer.²⁶ Currently though, there seems to be a consensus to use the 5-mm diameter as the threshold between clinically significant lesions diagnosed as neuromas and incidental US or MRI findings of enlarged nerves.^{17,18,28} We have used the same criteria in our study defining lesions only of greater than 5 mm in diameter as sonographic neuromas.

According to our findings, 54% of the study group had sonographic nerve thickenings detected with the US. As none of these patients suffered from forefoot pain, these can be considered "false positive" findings. Volpe et al reported no such false positive results in their series of operated Morton neuromas, all of which had a preoperative US.²⁵ Few previous studies have reported the US incidence of asymptomatic nerve thickenings in a normal population sample. Iagnocco et al.⁷ found "no significant changes of the structures examined" in 50 healthy subjects examined for Morton's neuroma. In the same study, only 10.9% of patients

with metatarsalgia were found to have interdigital neuroma according to the US findings. The authors do not clarify the diagnostic criteria used for the US confirmation of an interdigital neuroma. In both other studies, the study population was ten subjects and the findings of each were conflicting.^{8,18} In two previous studies based on MRI findings, the prevalence of asymptomatic nerve thickenings was 30% and 33%, respectively.^{1,28} In these studies however, lesions as small as 2 to 3 mm in diameter were recorded as neuromas. By using widely accepted diagnostic criteria, the present study also suggests that the prevalence of asymptomatic neuromas in the general population may be considerably (i.e., 54%) high.

We found no correlation between the patients' gender and the prevalence of sonographic neuromas. This is contrary to the symptomatic cases in which the predominance of women has been well documented. Indeed, an estimated 80% to 95% of patients suffering from Morton's neuroma are female.⁶

In the current study, patients with sonographic neuromas were on average about 10 years older than those with no neuromas detected. Their mean age was 51 years, which is similar to the usual age of onset of symptomatic neuromas.^{6,26} A positive correlation between age and the size of a peripheral nerve has also been found for the median nerve.^{3,27} It remains unclear whether these enlargements correspond to degenerative hypertrophic changes of the corresponding nerves.

In a comparative study using both US and MRI for confirming the clinical diagnosis of an interdigital neuroma, 20% "false-positive" US results were reported.²⁰ The authors clarify that these refer to neuromas detected in adjacent, asymptomatic web spaces. Similarly, in our study group there were 16 feet (16.3%) where neuromas were found in adjacent web spaces. Using MRI, Bencardino et al.¹ also report 16% of their asymptomatic neuroma patients to have concomitant neuromas in adjacent web spaces. Other authors report no false positive US examinations.¹⁶

Symptomatic interdigital neuromas are bilateral in about 10% of cases. In this series, 48% of patients with incidental interdigital nerve thickening had bilateral involvement. This may suggest that the frequency of sonographic neuromas contralateral to the symptomatic foot may be higher than previously reported. On the other hand, there was an equal distribution of neuromas in the second and third web spaces in the current study. Other authors have also noted this,¹³ although a number of clinical studies show a predilection for the third web space.²⁴ Finally, it has been noted that neuromas almost never occur in the first or fourth web spaces, which is in accordance to our findings.^{24,26}

The presence of another primary pathology in the studied feet was not related to the detection of sonographic neuromas. Moreover, the region of the primary pathology did not seem to influence the US results.

A palpable click felt over the affected web space by squeezing together the metatarsal heads has been described

by Mulder more than 50 years ago.¹⁴ At times, this diagnostic test was considered pathognomonic for the diagnosis of an interdigital neuroma; its significance is currently debated.²⁶ The prevalence of a positive Mulder's click in patients with Morton neuromas ranges from 27% to 84% in the literature.²⁰ In the current series, a click was produced in 17.7% of all examined feet and in 28% of the feet with sonographic neuromas. The finding of a Mulder's click in the examined feet was related to the subsequent sonographic detection of a neuroma, as in 13 of the 17 feet with this clinical finding a sonographic neuroma was found. On the other hand, more than one third of the feet without a Mulder's click were found to have an enlarged interdigital nerve. According to these findings, the negative predictive value of the test may not be strong, whereas the detection of a click gives a 76% chance that a sonographic neuroma is present.

CONCLUSION

In the present study the frequency of interdigital nerve thickenings in an asymptomatic patient group was considerably high. Further studies are needed in order for the prevalence of sonographic neuromas in the general population to be established. Our findings suggest that, in the absence of typical clinical findings, an isolated US report of a Morton's neuroma needs to be interpreted with caution by the treating physician. On the basis of these results, the accuracy and reliability of US studies in confirming the diagnosis of a neuroma in equivocal cases needs to be revisited.

REFERENCES

- Bencardino, J; Rosenberg, ZS; Beltran, J; Liu, X; Marty-Delfaut, E: Morton's neuroma: is it always symptomatic? *AJR Am J Roentgenol.* **175**(3):649–653, 2000.
- Betts, L: Morton's metatarsalgia neuritis of the fourth digital nerve. *Med J Aust.* **1**:514, 1940.
- Cartwright, MS; Shin, HW; Passmore, LV; Walker, FO: Ultrasonographic reference values for assessing the normal median nerve in adults. *J Neuroimaging.* **19**(1):47–51, 2009. <http://dx.doi.org/10.1111/j.1552-6569.2008.00256.x>
- Finlay, K; Friedman L: Ultrasonography of the lower extremity. *Orthop Clin North Am.* **37**(3):245–275, v, 2006. <http://dx.doi.org/10.1016/j.oocl.2006.03.002>
- Graham, CE; Graham, DM: Morton's neuroma: a microscopic evaluation. *Foot Ankle.* **5**(3):150–153, 1984.
- Hassouna, H; Singh, D: Morton's metatarsalgia: pathogenesis, aetiology and current management. *Acta Orthop Belg.* **71**(6):646–655, 2005.
- Iagnocco, A; Coari, G; Palombi, G; Valesini, G: Sonography in the study of metatarsalgia. *J Rheumatol.* **28**(6):1338–1340, 2001.
- Kaminsky, S; Griffin, L; Milsap, J; Page, D: Is ultrasonography a reliable way to confirm the diagnosis of Morton's neuroma? *Orthopedics.* **20**(1):37–39, 1997.
- Kankanala, G; Jain AS: The operational characteristics of ultrasonography for the diagnosis of plantar intermetatarsal neuroma. *J Foot Ankle Surg.* **46**(4):213–217, 2007. <http://dx.doi.org/10.1053/j.jfas.2007.04.001>
- Lassmann, G: Morton's toe: clinical, light and electron microscopic investigations in 133 cases. *Clin Orthop Relat Res.* **142**(142):73–84, 1979.
- Latinovic, R; Gulliford, MC; Hughes, RA: Incidence of common compressive neuropathies in primary care. *J Neurol Neurosurg Psychiatry.* **77**(2):263–265, 2006. <http://dx.doi.org/10.1136/jnnp.2005.066696>
- Lee, MJ; Kim, S; Huh, YM; Song, HT; Lee, SA; Lee, JW; Suh, JS: Morton neuroma: evaluated with ultrasonography and MR imaging. *Korean J Radiol.* **8**(2):148–155, 2007. <http://dx.doi.org/10.3348/kjr.2007.8.2.148>
- Mann, RA; Reynolds, JC: Interdigital neuroma—a critical clinical analysis. *Foot Ankle.* **3**(4):238–243, 1983.
- Mulder JD: The causative mechanism in morton's metatarsalgia. *J Bone Joint Surg Br.* **33-B**(1):94–95, 1951.
- Okafor, B; Shergill, G; Angel, J: Treatment of Morton's neuroma by neurolysis. *Foot Ankle Int.* **18**(5):284–287, 1997.
- Oliver, TB; Beggs, I: Ultrasound in the assessment of metatarsalgia: a surgical and histological correlation. *Clin Radiol.* **53**(4):287–289, 1998. [http://dx.doi.org/10.1016/S0009-9260\(98\)80128-1](http://dx.doi.org/10.1016/S0009-9260(98)80128-1)
- Pollak, RA; Bellacosa, RA; Dornbluth, NC; Strash, WW; Devall, JM: Sonographic analysis of Morton's neuroma. *J Foot Surg.* **31**(6):534–537, 1992.
- Redd, RA; Peters, VJ; Emery, SF; Branch, HM; Rifkin, MD: Morton neuroma: sonographic evaluation. *Radiology.* **171**(2):415–417, 1989.
- Shapiro, PP; Shapiro, SL: Sonographic evaluation of interdigital neuromas. *Foot Ankle Int.* **16**(10):604–606, 1995.
- Sharp, RJ; Wade, CM; Hennessy, MS; Saxby TS: The role of MRI and ultrasound imaging in Morton's neuroma and the effect of size of lesion on symptoms. *J Bone Joint Surg Br.* **85**(7):999–1005, 2003. <http://dx.doi.org/10.1302/0301-620X.85B7.12633>
- Shereff, MJ; Grande, DA: Electron microscopic analysis of the interdigital neuroma. *Clin Orthop Relat Res.* **271**(271):296–299, 1991.
- Sobiesk, GA; Wertheimer, SJ; Schulz, R; Dalfovo, M: Sonographic evaluation of interdigital neuromas. *J Foot Ankle Surg.* **36**(5):364–366, 1997. [http://dx.doi.org/10.1016/S1067-2516\(97\)80038-5](http://dx.doi.org/10.1016/S1067-2516(97)80038-5)
- Stamatis, ED; Karabalis, C: Interdigital neuromas: current state of the art—surgical. *Foot Ankle Clin.* **9**(2):287–296, 2004. [http://dx.doi.org/10.1016/S1083-7515\(03\)00156-6](http://dx.doi.org/10.1016/S1083-7515(03)00156-6)
- Thomson, CE; Gibson, JN; Martin, D: Interventions for the treatment of Morton's neuroma. *Cochrane Database Syst Rev.* **3**(3):CD003118, 2004.
- Volpe, A; Tognon, S; Fassina, A: Morton's syndrome: surgical strategies according to the digital nerve pathology. *Foot and Ankle Surgery.* (4):129–137, 1998. <http://dx.doi.org/10.1046/j.1460-9584.1998.00096.x>
- Weinfeld, SB; Myerson, MS: Interdigital Neuritis: Diagnosis and Treatment. *J Am Acad Orthop Surg.* **4**(6):328–335, 1996.
- Yao, L; Gai, N: Median nerve cross-sectional area and MRI diffusion characteristics: normative values at the carpal tunnel. *Skeletal Radiol.* **38**(4):355–361, 2009. <http://dx.doi.org/10.1007/s00256-008-0626-1>
- Zanetti, M; Strehle, JK; Kundert, HP; Zollinger, H; Hodler, J: Morton neuroma: effect of MR imaging findings on diagnostic thinking and therapeutic decisions. *Radiology.* **213**(2):583–588, 1999.