

# Ultrasound-guided radiofrequency ablation in the management of interdigital (Morton's) neuroma

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## Abstract

**Objective** To identify the benefits of ultrasound-guided radiofrequency ablation of Morton's neuroma as an alternative to surgical excision.

**Materials and methods** We studied a consecutive cohort of surgical candidates for Morton's neurectomy who we referred, instead, for radiofrequency ablation (RFA). Under local anaesthetic, RFA was performed under ultrasound guidance, by a single radiologist. This out-patient procedure was repeated after 4 weeks if necessary. We followed patients for a minimum of 6 months to assess their change in visual analogue pain scores (VAS), symptom improvement, complications and progression to surgical excision.

**Results** Thirty feet in 25 patients were studied. There were 4 men and 21 women with an average age of 55 years (range 33–73 years). All had tried previous methods of conservative management. Forty percent presented with 2nd space neuromas and 60% with 3rd space ones. The average number of treatment sessions was 1.6 (range 1–3, mode 1). Prior to treatment, all patients had pain on activity (VAS average: 6.0, range 3–9). Post-treatment there was a statistically significant reduction in pain scores (post-RFA VAS average:

1.7, range 0–8,  $p < 0.001$ ). The average overall symptom improvement was 76%. There was one minor complication of temporary nerve irritation. Three neuromas (10%) have progressed to surgical excision; 1 patient has ongoing, unchanged pain with no obvious cause. At 6 months, 26 out of 30 feet had a satisfactory outcome.

**Conclusion** Ultrasound-guided RFA has successfully alleviated patients' symptoms of Morton's neuroma in >85% of cases. Only 10% have proceeded to surgical excision in the short term.

**Keywords** Morton · Interdigital · Neuroma · Ultrasound · Radiofrequency · Ablation · Denervation

## Introduction

The initial management of symptomatic interdigital neuromas is usually non-operative. This includes activity and footwear modification, orthoses and Achilles tendon stretching. More invasive approaches include cryoablation or injections of local anaesthetic, corticosteroid, phenol or alcohol. Many patients will gain some benefit from these conservative measures. However, up to 70% may still proceed to surgery because of ongoing symptoms.

The success of surgical excision is up to 85% [1], but this carries its own morbidity including infection, numbness, painful scar formation and symptomatic stump neuroma. Radiofrequency ablation (RFA) is a less invasive alternative. This involves inserting a needle probe into the neuroma and generating a high frequency, alternating current that causes heat necrosis of the nerve tissue.

Previous studies have demonstrated success in the use of RFA, reducing the need for surgery in up to 80% of patients [2]. We studied the use of ultrasound-guided RFA to identify if better results could be obtained through the use of direct imaging at the time of treatment.

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## Materials and methods

The authors undertook a retrospective review of all consecutive patients referred from our clinic for RFA for Morton's [3] neuroma between January and September 2011, with a minimum of 6 months' follow-up. The research was performed following the Declaration of Helsinki principles.

All patients had initially presented to our clinic with a provisional diagnosis of Morton's neuroma. Some had been confirmed with ultrasound imaging or MRI but most referrals were based on clinical history and examination alone. Patients had all tried—and were unsatisfied with—conservative treatment and had presented for surgical consideration. Following diagnostic confirmation through history and clinical examination, patients were referred to a local interventional radiology centre for RFA under ultrasound guidance by a single, experienced, radiologist (DC).

Included in the study were all patients presenting with a diagnosis of primary Morton's neuroma. We excluded patients with previous excision or recurrence (e.g. stump neuromas) and one patient with neurofibromatosis.

Patients were contacted at least 6 months after their final RFA treatment. After giving verbal consent to inclusion in the study, they were questioned regarding their duration and severity of symptoms, and previous treatments tried. Further data were recorded including site, side and size (if documented) of neuroma and any other local forefoot pathology. Any complications of the procedure were noted.

The foot and ankle were cleaned with a surgical skin prep solution (chlorhexidine 0.5%) and sterile drapes applied. A local anaesthetic block of the tibial nerve was performed by injection of 4 ml of bupivacaine 0.25% (Pfizer) posterior to the medial malleolus under ultrasound guidance (Philips HDI, 5–17 MHz transducer) with a sterile probe cover. A further injection of local anaesthetic (1 ml of bupivacaine 0.25%) with 4 mg of dexamethasone (Hospira) was injected locally around the neuroma.

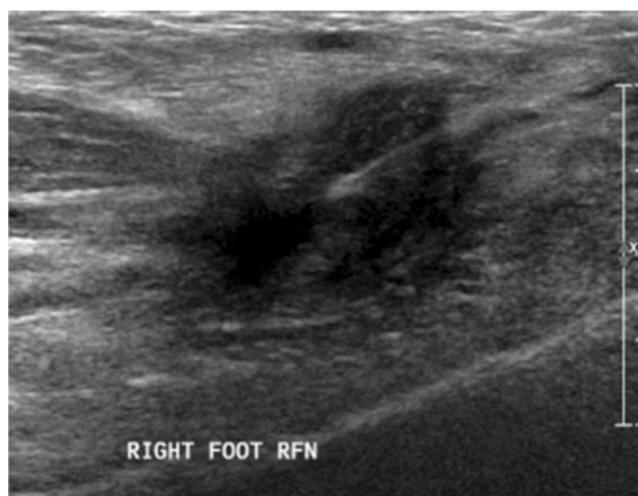
After 5–10 min, once the local anaesthetic had taken effect, the RFA was commenced. The machine was a Neurotherm NT 500 with ground leads placed on the patient's thigh. Under ultrasound guidance, the sterile radiofrequency needle probe (22 G 5 cm needle with 10 mm electrode tip) was inserted between the toes, into the appropriate web-space (Fig. 1), and into the heart of the neuroma (Fig. 2). Five cycles of 2 min each were used, with the probe tip maintaining a temperature of 81°C (impedance 90–250 Ω).

The procedure was performed in an out-patient clinic setting. Patients were discharged home as soon as comfortable with instructions to rest for the remainder of the day. They could use ice and paracetamol as necessary and could mobilise the following day as comfort allowed.



**Fig. 1** The radiofrequency needle in situ with the ultrasound probe visible

Patients were reviewed 4 weeks later with a follow-up ultrasound scan and RFA was repeated if still symptomatic. If patients were unsatisfied after three treatment sessions, they were referred back to our clinic for further management. If the symptoms had changed or the diagnosis was inconclusive, the patient was referred for further investigations as appropriate (e.g. MRI, nerve conduction studies etc.). If the symptoms and clinical examination remained consistent with Morton's neuroma, the patient was offered a surgical excision. This was performed routinely through a dorsal, intermetatarsal approach under general anaesthetic as a day case procedure. A neurectomy was performed and the resected nerve sent for histopathological confirmation.



**Fig. 2** Ultrasound image of the radiofrequency needle probe in the centre of the neuroma

## Results

Thirty feet in 25 patients were included in our study. All had RFA treatment performed by a single radiologist between February and September 2011. The mean age was 55 years (range 33–73 years). There were four men and 21 women (ratio 1:6.25). The mean duration of symptoms prior to RFA was 3.8 years (range 6 months to 15 years).

All patients had previously tried and failed some form of conservative management, i.e. they had persistent or recurrent symptoms that warranted further treatment. Twenty (80%) had tried orthotics and 15 (60%) had tried cortisone injections. Thirteen patients described the symptoms as a “nuisance” while 12 described them as “disabling”, representing the need to significantly modify their everyday activity. Regarding their level of sporting activity, 18 described it as “minimal”, 4 were involved in regular sport, and 3 were involved at a high or competitive level. Three patients had asymptomatic bilateral bunions (hallux valgus), of whom 2 had bilateral symptomatic neuromas.

Prior to RFA treatment, 4 patients had pain at rest; all patients had pain on activity. Pain scores on activity were measured using the Visual Analogue Scale (0=no pain; 10=worst pain ever). Statistical analysis was performed using a paired *t* test, the results of which are shown in Table 1.

Nineteen were left feet and 11 were right. Twelve (40%) neuromas presented in the 2nd webspace, while 18 (60%) presented in the 3rd. All patients had neuromas confirmed at the time of ultrasound, described as a “focal, well-circumscribed anechoic lesion in the interdigital webspace”. However, 8 feet were found to have an additional neuroma in the adjacent webspace (2nd or 3rd); this was also treated with RFA at the same sitting.

The size of the neuromas before RFA (measured on ultrasound as the diameter of greatest length or width) ranged from 4 to 21 mm (average 10.7 mm). Measurements were attempted post-RFA at follow-up visits, but these were far less reliable due to the much less distinct appearance of the treated neuroma; they appeared ill-defined with surrounding fibrosis and/or oedema.

The average number of RFA treatment sessions required was 1.6 (range 1–3, mode 1). The average overall symptom improvement, as described by the patient, was 76% (range 0–100).

**Table 1** Results of the statistical analysis

		Pre-RFA	6 months post-RFA	
VAS pain score (0 to 10) on activity	Mean	6.0	1.7	$p < 0.001$
	Range	3–9	0–8	

Eight patients (32%) described the experience as unpleasant, but they would all have undergone the procedure again, as first-line treatment, instead of surgery. Those who underwent surgery said they found the RFA treatment preferable and did not regret undergoing this first. One patient experienced irritation of the posterior tibial nerve for 3 weeks following the procedure; this completely resolved. Otherwise, there were no complications.

We found no statistically significant correlation between pain or outcome with any of the following factors: age, gender, site, size, number, symptom duration, activity level or previous treatment. Specifically, we analysed the difference in outcomes between 2nd and 3rd space neuromas. We excluded all feet with neuromas in more than one space, leaving 9 feet with isolated 2nd webspace neuromas and 13 feet with 3rd webspace neuromas. Although the mean reduction in VAS was higher in the 3rd webspace group (4.3 versus 3.3), this difference was not statistically significant in our study ( $p = 0.299$ ).

Three neuromas (10%), despite having symptom improvement, have since progressed to surgical excision; 1 patient had no improvement post-RFA; 1 patient described 40% improvement, but still wanted surgery; 1 patient had 100% improvement initially, but her symptoms had completely recurred within 6 months. In all 3 patients, subsequent surgery completely resolved their symptoms. One other patient, who denied any improvement following RFA, has undergone multiple further investigations, which showed no other obvious cause of his symptoms. He is not being considered for surgery. At 6 months, 26 out of 30 feet (86.7%) had a satisfactory outcome, without the need for surgical excision.

## Discussion

Radiofrequency ablation has been used for many years in other specialty areas including cardiology, neurosurgery and oncology. It has gained popularity relatively recently in the management of distal neurological problems, e.g. stump and interdigital neuromas.

Previous publications have studied the use of RFA in the treatment of Morton’s neuromas, but we could find none that used ultrasound localisation in their treatment protocol. In Genon et al.’s [2] study, 11 out of 38 patients (28.9%) proceeded to open neurectomy; the time to surgery was not detailed. Patients in this study were awake in theatre when the probe was inserted; when the point of maximal tenderness was experienced, propofol sedation was administered and the RFA commenced. In Moore et al.’s study [4], 83% of patients expressed complete relief of symptoms within 1 month of treatment; only 1 out of 29 patients proceeded to surgical excision. Patients had their maximum point of

tenderness marked on the skin before the procedure; they were then anaesthetised in theatre and X-ray fluoroscopy was used to confirm the electrode placement in the intermetatarsal space. Both studies required the use of operating theatre time, space, personnel and equipment, as well as general anaesthetic. Our technique demonstrated a satisfactory outcome in 26 out of 30 feet (86.7%) with 3 patients (10%) proceeding to surgical excision within 6 months. This compares favourably with the limited number of studies available in the current literature.

The benefits of this technique include the visualisation of the needle tip within the neuroma when administering the radiofrequency treatment. This has multiple advantages: confirmation and accuracy of needle placement; prevention of iatrogenic injury to other local tissues; provision of visual documentation in cases of litigation. Furthermore, the use of ultrasound can help in the diagnosis of other local pathology, e.g. synovitis, bursitis or tendon pathology. It is performed as an outpatient procedure in the radiology department, precluding the need for operating theatre space and anaesthetic team involvement, thereby reducing the overall cost of treatment.

Our sample size is comparable to other studies. We acknowledge that the follow-up is limited, but the results are very encouraging, even in the short-term. Although RFA has been used successfully in the treatment of stump neuromas, we excluded them from our study to minimise variability. Likewise, we also excluded patients presenting with potentially confounding pathologies (e.g. neurofibromatosis) or ongoing pain following previous neurectomy. Therefore, only patients with a diagnosis of primary Morton's neuroma were included in the study.

We acknowledge the use of steroid injection at the time of the procedure. This was performed by the radiologist to reduce post-procedural pain and inflammation. One could argue that this alone provided the results presented. However, we know that the success rate of steroid injection is variable—even under ultrasound guidance [5] (29% had complete relief at 9 months)—and that the benefit is often temporary. Furthermore, 15 patients (60%) in our study cohort had failed previous corticosteroid injection, i.e. their symptoms persisted or recurred sufficiently to warrant further intervention. Of course, this may have been due to poor injection technique rather than poor efficacy; unfortunately, the documentation regarding injections prior to referral was, in most of our cases, lacking. None of the patients recalled having the injection done under ultrasound guidance, although this may have affected the outcome.

Cryoablation and alcohol injections are other treatment modalities with reported success. In Caporusso et al.'s study [6], 31 lower limb neuromas underwent percutaneous cryoablation: 39% had complete pain relief, 45% partial (VAS score reduction from 8.5 to 3.5), with 5 patients requiring

subsequent surgical neurectomy. There was a low reported complication rate with high patient satisfaction. Although this study appears to demonstrate a viable treatment option, there are very few published series available specifically for Morton's neuromas.

The use of alcohol or phenol injections has been more extensively documented, the latter mainly in regard to the management of stump neuromas. Magnan et al. [7] treated 71 cases of Morton's neuroma with local, percutaneous phenol injection providing effective pain relief in 80% after a mean follow-up of 36 months. In Hughes et al.'s study [8], 101 patients had 20% ethyl alcohol injected under ultrasound guidance: 84% classified themselves as completely pain-free, but only 62% were completely satisfied with their treatment. They required an average of 4.1 visits for treatment and found the injections moderately painful. 16.8% had increased plantar pain that lasted up to 3 weeks. The senior author (DC) now prefers to use radiofrequency ablation as he feels the procedure is better tolerated with fewer treatment sessions required and fewer local side effects; RFA targets a more controlled area, while alcohol injections can spread locally, causing fat necrosis, for example. A more recent, smaller study of ultrasound-guided alcohol injection [9] showed a 66% response rate after 14 months, with 20% still requiring subsequent surgery. Another treatment option may be to combine radiofrequency with alcohol injections, but this would require further study.

We found no predictive factors for good or poor outcome. Womack et al. [10] found worse outcomes in 2nd space neuromas compared with 3rd space ones, but their study included larger numbers. Our study data tend to agree with this finding, but our difference in improvement did not reach statistical significance. As with most other studies, there seems to be no correlation between size of the lesion and pain; however, the measurement of size is purely subjective. Perhaps a more representative measurement—rather than length—would be the cross-sectional area of the neuroma, particularly for the RFA technique; a very large neuroma may require more cycles of RFA treatment at each sitting. Another option would be to treat the nerve immediately proximal to the neuroma; to our knowledge, this has not yet been reported in the literature.

Patients who had RFA treatment at the same sitting for adjacent webspace neuromas all had good outcomes. As the adjacent neuroma was an incidental finding at the time of ultrasound, it is not clear which one, or both, was causing the majority of symptoms. Most surgeons try to avoid excising neuromas in adjacent webspaces if possible; some prefer to excise one neuroma while performing neurectomy on the other. Although our numbers are relatively small, we experienced no adverse outcomes by treating both neuromas with RFA in these patients.

Concerns about scar formation complicating future surgery have not been borne out by the operating surgeon

(MB). In his experience, although the appearance of the neuroma is altered after RFA (firm, scarred or locally adherent), it is no more difficult to trace the neuroma from its nerve proximally and dissect distally. Anecdotally, he has not noticed a significant increase in operating time or complication rate and all patients have had an excellent outcome.

The protocol for RFA treatment in our study (temperature, time, cycles etc.) was developed from previous work done on spinal facet joint denervation within this radiology department. Further research will need to be done to identify the optimal technique for interdigital neuromas; as mentioned above, this may also need to take into account the size or volume of the neuroma.

We have demonstrated a very low complication rate with this technique. It prevents many complications normally associated with surgical excision, as well as the time required to recover from surgery. It appears that overall satisfaction is similar to that of surgical excision [11], but without the need for, and risks of, surgery. Although these results are very encouraging, potentially reducing the need for surgical excision, we would recommend longer term studies with larger numbers of patients.

## Conclusion

The short- to mid-term results of radiofrequency ablation for the treatment of interdigital neuromas are very encouraging. There is a high level of symptom improvement with a reduction in the need for surgical excision by over 85%. It appears to be a safe and effective, minimally invasive alternative for the treatment of symptomatic Morton's neuromas.

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**Conflict of interest** The authors declare that they have no conflict of interest.

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