ORIGINAL RESEARCH

A Retrospective Study of Radiofrequency Thermal Lesioning for the Treatment of Neuritis of the Medial Calcaneal Nerve and its Terminal Branches in Chronic Heel Pain

Joseph A. Cione, DPM, DABPS, FACFAS; John Cozzarelli, DPM, DABPS, FACFAS and Christopher Jay Mullin, DPM, DABPS, FACFAS

We undertook a retrospective analysis of 75 consecutive patients with recalcitrant plantar heel pain caused by calcaneal neuritis, all who were treated with radiofrequency thermal lesioning (RTL). The median age of the cohort was 55 (range 24 to 83) years, 25 (33.3%) of the patients were male, 50 (66.7%) of the patients were female, and 15 (20%) of the patients were treated for bilateral heel pain caused by medial calcaneal neuritis. The median preoperative VAS score was 9 (range 2 to 10), whereas the median long-term postoperative VAS score was 1 (range 0 to 8), and this difference was highly statistically significant ($P < .0001$*). Five (6.7%) of the patients experienced recurrent heel pain, over a median follow-up duration of 18 (range 12 to 36) months. Overall, 93.3% of the patients experienced satisfactory pain relief with radiofrequency lesioning for the treatment of recalcitrant plantar heel pain caused by medial calcaneal neuritis. Level of Clinical Evidence: 2* (The Journal of Foot & Ankle Surgery 48(2): 142–147, 2009)

Key Words: calcaneus, nerve ablation, nerve entrapment, radio frequency

Plantar heel pain is generally understood to be one of the most common presenting complaints encountered by the foot and ankle specialist, and a variety of etiological factors comprise the differential diagnosis for plantar heel pain. Although a wide range of conservative treatments are used in the management of plantar heel pain, the pain may persist and become recalcitrant despite seemingly appropriate therapy. An overlooked, and sometimes undiagnosed clinical entity that may be responsible for plantar heel pain is entrapment of the medial calcaneal nerve (1–4). Tanz (5) concluded that inferior heel pain is caused by irritation of a branch of the medial calcaneal nerve. Henricson and Westlin (2) analyzed 10 adults with chronic heel pain who were unresponsive to conservative treatment, and concluded that the patients' symptoms were a result of compression of the anterior calcaneal nerve branch by the deep fascia of the abductor hallucis and, therefore, they recommended treatment by means of open external neurolysis. It is common to have a neurogenic component to be the cause of plantar heel pain (6). It has been documented in the literature that a neuroma of the medial calcaneal nerve branch as a cause of heel pain (1, 7). Heel neuromas are caused by the micro or macro trauma of bipedal ambulation on unyielding weight-bearing surfaces such as concrete and asphalt (1). Repeated ambulation in the form of walking, running, or the work environment can cause micro trauma leading to inflammation of the nerve sheath. Chronic irritation of a nerve in an elbow, face, or hip results in inflammation of the nerve sheath, causing proliferation of the perineural connective tissues (8). Recurrent irritation can lead to chronic neuritis and ultimately hypertrophy of the nerve sheath fibers (9).

Address correspondence to Joseph A. Cione, DPM, Podiatry Associates of Belleville, PC, 155 Belleville Avenue, Belleville, NJ 07109. E-mail: Fixfoot@aol.com.

Podiatry Associates of Belleville, Belleville, NJ.

Financial Disclosure: None reported.

Conflict of Interest: None reported.

1067-2516/09/4802-0009$36.00/0

doi:10.1053/j.jfas.2008.11.007

Davidson and Copoloff (1) described a neuroma of the medial calcaneal nerve branch as a cause of heel pain syndrome. Shandles et al's (7) study reviewed 317 cases of plantar heel pain, where 60 required surgical excision of a heel neuroma that were subsequently verified histologically with changes virtually identical with the classic Morton's neuroma. Rose et al (10) showed that entrapment of the medial calcaneal nerve plays an important role in the development of plantar heel pain; they were able to quantify abnormal sensibility in the cutaneous distribution of both the medial calcaneal nerve and/or the medial plantar nerve in a significant number of patients in plantar heel pain. Eighty-two patients with a chief complaint of plantar heel pain were evaluated for sensory abnormalities within the cutaneous distribution of both the medial calcaneal nerve and the medial plantar nerve using quantitative neurosensory testing with a pressure-specified sensory device. The results showed that 72.17% of the patients displayed abnormal sensory function within the distribution of the medial calcaneal nerve (10). In a recent study, a series of 25 patients with heel pain, Oztuna et al (11) found that 22 heels (88%) with heel pain had lateral plantar nerve entrapment signs with or without medial plantar nerve findings on electromyography (EMG).

When ordinary heel pain attributed to plantar fasciitis does not respond to conservative care or there are changes in the symptoms during the conservative or surgical treatment phase, clinicians should start to think about nerve entrapment as being a the culprit (12). The diagnosis of medial calcaneal nerve entrapment is usually one of exclusion and is often only considered after failure of standard measures used for the treatment of mechanical heel pain.

Radiofrequency thermal lesioning (RTL) works by means of lateral heat dissipation from the active electrode. In essence, an insulated electrode is placed into the tissues that are to be treated. When the electrical generator source is connected to this electrode, the impedance of the surrounding tissue conducts the electromagnetic energy (radio wave) from the generator source into the tissues, thereby generating heat in the involved tissues. The current spreads into the surrounding tissues as it leaves the tip of the electrode, raising the temperature of the tissues to the point where proteins denature and physiological function is disrupted. Precise placement of the tip of the electrode at the site of maximum pain is critical, because the tissues directly adjacent to the active electrode are heated (hence, damaged) the most (13). This causes destruction of the peripheral nerve endings, as well as the myelin sheath, at the site of maximal heel tenderness.

RTL has been used in the treatment of a number of clinical entities including trigeminal neuralgia, lumbar disc herniation, coronary vascular disease, cardiac arrhythmia, cervical pain syndrome, and essential tremor. The use of RTL in the foot has been reported in regard to the treatment of Morton's neuroma, verrucae, and ingrown toenails (13). Percutaneous radiofrequency ablation of an osteoid osteoma involving the calcaneus was performed by Migues et al (14), and resulted in relief of pain without evidence of recurrence of symptoms or the lesion at a 3-year follow up. Solitto et al (13) performed RTL for resistant plantar fasciitis that was unresponsive to conservative treatments in 39 patients, and reported that 92% of the patients experienced complete resolution of symptoms following the procedure. Based on our understanding of the literature related to the use of RTL for conditions involving nerve pain, and because we believe that recalcitrant plantar heel pain, while initially presenting as plantar fasciosis, often involves neuritis of the medial calcaneal nerves near the attachment of the plantar fascia to the calcaneus, we undertook a retrospective cohort investigation to evaluate the effectiveness of RTL in the treatment of plantar heel pain unresponsive to traditional therapeutic measures.

Name: Age:

Patient ID #:

1. Which heel was causing you pain? Right Left Both

2. How long have you experienced the heel pain? 0-6mos. 7-12mos. Over 12 mos.

3. Please circle previous treatments received: anti-inflammatory medication, steroid injections, shoe inserts/orthotic, physical therapy, taping/strapping, home stretching, open heel surgery.

4. Using the pain scale below, please rate your pain level before the procedure:

0	1	2	3	4	5	6	7	8	9	10
No Pain										Severe Pain

5. Which heel was treated using radio frequency? Right Left Both

6. Are you currently using custom-made esthetics? Yes No

7. Using the pain scale below, please rate your pain level following the radio frequency procedure.

0	1	2	3	4	5	6	7	8	9	10
No Pain										Severe Pain

8. How would you rate the overall success of the radio frequency procedure?

Completely Successful - Very Successful - Moderately Successful - Marginally Successful - Not Successful at all.

9. What % of improvement in this heel pain have you experienced since the radio frequency procedure?

10. Would you have this procedure performed again if applicable? Yes or No.

11. Would you recommend this procedure to a friend or family member? Yes or No.

FIGURE 1 Radiofrequency thermal lesioning questionnaire.

Patients and Methods

We reviewed the records of all of the patients who had undergone RTL for the treatment of recalcitrant plantar calcaneal heel pain, initially diagnosed as proximal plantar

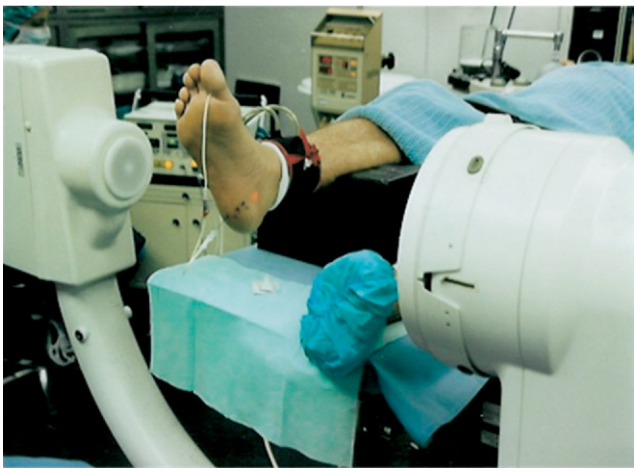

FIGURE 2 After palpating the heel and marking the points of maximum tenderness, the foot is prepped and draped and a pneumatic ankle tourniquet inflated, after which the osseous structures of the plantar heel are visualized using fluoroscopic image intensification.

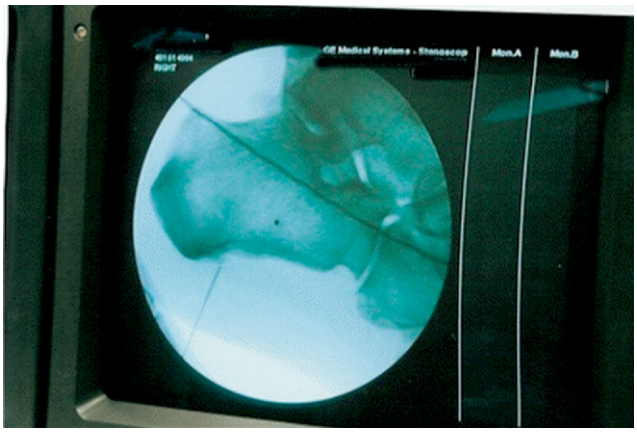

FIGURE 3 Fluoroscopic placement of a 22-gauge cannula with a solid stylet inserted into the first marked site.

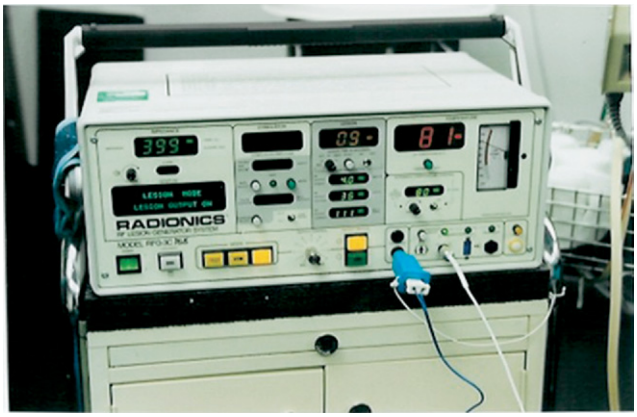

FIGURE 4 The radio energy generator (Radionics RFG-3C Lesion Generator, Radionics, Inc., Burlington, MA).

fasciosis, and ultimately identified as medial calcaneal neuritis, during the time period extending from January 2000 to January 2003. The initial diagnosis of proximal plantar fasciosis was made based on clinical and radiographic, as well as ultrasonography, findings. In 2004, each of the patients who had undergone RTL was sent a survey (Figure 1) in an effort to evaluate their long-term results following the procedure. At that time, moreover, each patient was also asked to rate their current level of pain, and to recall their preoperative level of pain, using a 10-cm visual analog scale (VAS) rating system.

Before undergoing RTL, for each of the patients, conservative treatment was attempted for at least 6 months, and included the use of oral anti-inflammatory medications, local corticosteroid injections, foot orthotics, physical therapy, padding and strapping, a home stretching program, and the use of a plantar fascia night splint. When conservative treatment failed and the plantar heel pain persisted, further diagnostic testing was performed on each of the patients. An electrodiagnostic sensory nerve conduction threshold (sNCT) test was performed on each patient using the Neurometer CPT Device (Neurotron Inc., Baltimore, MD), which measures the current perception threshold (CPT) of the sensory nerve. The neuroselective sNCT test is capable of documenting abnormalities in both large and small fibers (15), and it is capable of measuring sensory dysfunction ranging from the hyperesthesia associated with early nerve irritation to hypoesthesia associated with profound loss of sensory function (16, 17). Every patient who had an abnormal sNCT result was considered a candidate for the RTL procedure. RTL was attempted on consecutive patients who failed 6 months or more of conservative treatment for their plantar heel pain, if they also had an abnormal sNCT result.

Before entering the operating room, each patient's heel was palpated and the area or areas of maximum tenderness were indicated with a marking pen. Following identification of the specific areas of tenderness, the patient was administered general anesthesia and the involved foot was prepped and draped in a sterile fashion. An ankle tourniquet was inflated to 250 mm Hg following exsanguination of the foot and ankle (Figure 2). Under fluoroscopic guidance, a 22-gauge cannula with a solid stylet was inserted into the first marked site (Figure 3). After proper placement of the cannula and stylet at the level of the proximal attachment of the plantar fascia, the inner stylet was removed leaving the 22-gauge cannula in place. It is through this cannula that the insulated radiofrequency probe was inserted and then connected to the radio energy generator (Radionics RFG-3C Lesion Generator, Radionics, Inc., Burlington, MA) (Figure 4). After confirming placement of the electrode fluoroscopically, muscle stimulation was performed with the electrode at low energy to ensure that the tip of the electrode was not in a muscle belly. The energy required to stimulate muscle

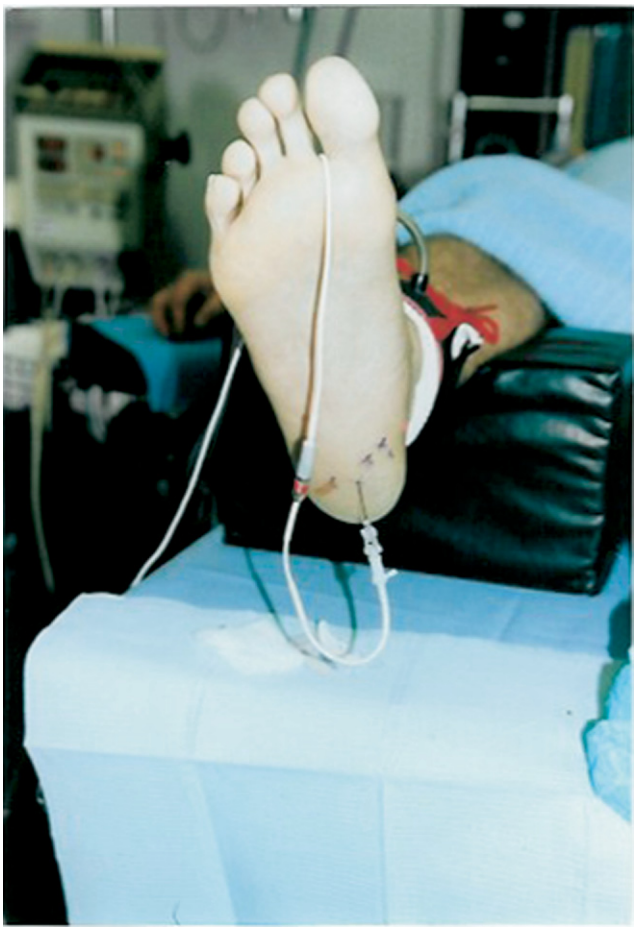

FIGURE 5 Radiofrequency thermal lesioning lead inserted into the plantar heel.

is much lower than that required to cause radiofrequency thermal lesioning. During this process of muscle stimulation, if any gross movement of the digits or if any muscle fasciculation was evident, the cannula was redirected. It is important that the tip of the electrode not be in muscle, rather it should be placed at the level of the plantar fascia attachment to the calcaneus or, if a distally elongated shelf-like plantar calcaneal spur is present, at the tip and just plantar to the spur. After confirming proper placement of the electrode, the thermal lesion was produced using radiofrequency heat at 86°C for 105 seconds (Figures 5 and 6). The area was lesioned for a total of 90 seconds, following a 15-second lead-in time during which the Radionics RFG-3C Generator reached the optimal temperature of 86°C. The lesioning process was repeated at each of the marked areas on the heel, after which 10 milliliters of a mixture of 8 mL of 1% lidocaine plain with 1 mL of 0.5% bupivacaine plain and 1 mL of triamcinolone acetonide (40 mg/mL) was injected in each of the treated sites. Following the injections, small bandages (coverlets) were applied to the involved sites on the heel, and the patient was allowed to

FIGURE 6 Radiofrequency thermal lesioning of the plantar heel, at a site different from that depicted in Figure 5.

return to shoe gear immediately following the procedure and was able ambulate on the foot as tolerated. No other postoperative medications were provided, and the patient was instructed to ambulate as desired, and to follow up at scheduled visits. Patients were also instructed to continue with supportive shoe gear and orthoses, and to continue stretching, if they desired.

Results

A total of 75 consecutive patients, who underwent RTL for a total of 90 heels with medial calcaneal neuritis, were retrospectively evaluated. Of these patients, 25 (33.3%) were male, 50 (66.7%) were female, and the overall median age was 55 (range 24 to 83) years (mean 55.8 ± 13.9 years). Fifteen (20%) of the patients had the procedure performed on both feet. The median duration of follow-up was 18 (range 12 to 36) months. The most common areas of tenderness to palpation before administration of the RTL were noted along the medial aspect of the calcaneus, and along the central aspect of the plantar heel region. The average number of areas lesioned was 6 per foot. Each patient was asked to rate his or her heel pain using a 10-cm VAS. The median preoperative VAS score was 9 (range 2 to 10), whereas the median long-term postoperative VAS score was 1 (range 0 to 8), and this difference was highly statistically significant ($P < .0001$) (Table 1). Overall, an approximately 79.7% reduction in pain, as measured by the 10-cm VAS, was observed following RTL. Overall, 5 (6.7%) of the patients experienced recurrent plantar heel pain, although none of the patients related any worsening of their pain in comparison to their preoperative status. There were no observed wound complications in this cohort, and all of the patients were able to ambulate in their regular shoes immediately following the RTL procedure.

TABLE 1 Comparison of preoperative to postoperative pain* (N = 90 heels in 75 patients)

Preoperative pain, median (range)	Postoperative pain, median (range)	*P* value, Wilcoxon signed ranks test
9 (2, 10)	1 (0, 8)	< .0001

*Patients graded their pain on a 10-cm visual analog scale, with 0 = no pain, and 10 = severe pain.

Discussion

A number of previously published reports (1–7, 10, 11), as well as the results of this cohort study, suggest that entrapment of the medial calcaneal nerve and heel neuroma are possible causes of recalcitrant plantar heel pain**.** In such cases, resection of the inflamed medial calcaneal nerve could be considered to be the last reasonable therapeutic intervention (1). When entrapment has led to formation of a neuroma-in-continuity, neurotomy and internal neurolysis have been considered (18, 19). RTL is a procedure that enables destruction of a peripheral nerve, hence resolution of pain associated with the nerve lesion, without the need for performing an open dissection of the heel. This type of intervention, while conveying some potential complications, allows a faster recuperation for the patient and a minimal recovery period, in comparison to more traditional methods of open surgical dissection. In an investigation by Solitto et al (13), RTL was used to treat 39 patients with resistant plantar fasciitis, and 92% of the patients in that study experienced complete resolution of their symptoms. In the investigation that we describe in this report, our success rate of 93.3% was very similar to that described by Solitto et al (13). In regard to potential causes of failure to adequately respond to RTL for plantar heel pain caused by calcaneal neuritis, a number of conditions come to mind. Subcutaneous bleeding following placement of the cannula can adversely affect the procedure by altering the resistance of the tissues surrounding the tip of the active electrode, thereby preventing the thermal reaction necessary to produced enervation (13). The procedure is also operator dependent, and inaccurate placement of the electrode in the heel can affect the outcome of the procedure. Furthermore, variation in the anatomy of the nerves located at the plantar and medial aspects of the heel could affect the outcome. For this reason, it is important to identify all of the focal areas of pain associated with the heel, and to precisely apply the RTL to each of these sites. Awareness that multiple calcaneal branches may innervate the heel suggests that surgery for heel pain of neural origin must employ a surgical approach that permits identification of all possible calcaneal branches (6). In 2002, Dellon et al (20) described the results of an anatomical study in which the medial and plantar aspects of the heel were innervated by just one medial calcaneal nerve in 37% of the feet, by 2 medial calcaneal nerves in 41% of the feet, by 3 medial calcaneal nerves in 19% of the feet, and by 4 medial calcaneal nerves in 3% of the feet. If all of the terminal branches innervating the medial heel are not addressed by RTL, then the procedure can fail. If the patient has difficulty in identifying the exact areas of tenderness, if the tip of the electrode is in the adjacent skeletal muscle belly, or if an adequate temperature is not sustained for a long enough period of time, the tissues intended for lesioning may not be completely denervated and symptoms may persist.

Although 5 (6.7%) of our patients experienced recurrent heel pain, none of them displayed any findings consistent with other potential complications related to RTL. We feel that accurate placement of the electrode is a vital component in avoiding a possible complication related to the procedure. In theory, if the electrode tip is in close proximity to the bone, a periosteal burn could occur. In contrast, if the tip of the electrode is too superficial at the skin level, a skin burn wound or ulceration could occur at the lesioning site. Furthermore, excessive lesioning of the plantar heel can potentially cause atrophy of the fat pad or complete denervation of the entire plantar aspect of the heel.

We recognize that our retrospective cohort study conveyed a number of methodological shortcomings that could threaten the validity of our conclusions. Although the 10-cm VAS pain scale is known to be a valid health measurement, the method in which it was used in this investigation, wherein patients were asked to recall their preoperative level of pain, was subject to recall bias because a long period of time had passed since they had undergone the RTL procedure. Moreover, we do not know how much of the clinical response was related to the injection that was administered following the RTL procedure, to continuation of any of the supportive measures, or simply to the passage of time following the RTL procedure. However, since the heel pain in each of the cases was recalcitrant, it is very likely that the RTL procedure had a clinically significant influence on the outcome.

In conclusion, the use of RTL has shown its effectiveness in the treatment of a cohort of 75 patients who suffered with recalcitrant plantar heel pain of a neurogenic origin. The procedure requires specialized RTL equipment, as well as precise placement of the active electrode by means of fluoroscopic image intensification. Although the procedure did not relieve pain in every case, it did so in 93.3% of the patients, and was shown to be safe and associated with a rapid return to regular shoes and weight-bearing activity.

References

1. Davidson MR, Copoloff JA. Neuromas of the heel. Clin Podiatr Med Surg 7:271–288, 1990.

2. Henricson AS, Westlin NE. Chronic calcaneal pain in athletes: entrapment of the calcaneal nerve? Am J Sports Med 12:152–154, 1984.
3. Savastano AA. Surgical neurectomy for the treatment of resistant painful heel. R I Med 68:371–372, 1985.
4. Dellon AL. Deciding when heel pain is of neural origin. J Foot Ankle Surg 40:341–345, 2001.
5. Tanz SS. Heel pain. Clin Orthop 28:169–178, 1963.
6. Kim J, Dellon AL. Neuromas of the calcaneal nerves. Foot Ankle Int 40:341–345, 2001.
7. Shandles ID, Pruchniewski J, Reynolds KL. Heel neuroma: the enigma of recalcitrant heel pain and an innovative approach highlighting sixty surgical cases and a review of two hundred and fifty-seven symptomatic but non-surgical cases. The Foot 12:10–20, 2002.
8. Spinner M, Spencer PS. Nerve compression lesions of the upper extremity—a clinical and experimental review. Clin Orthop 138:46–47, 1974.
9. Beito SB, Krych SM, Harkless LB. Recalcitrant heel pain: traumatic fibrosis versus heel neuronal. J Am Podiatr Med 79:336–339, 1991.
10. Rose JD, Malay DS, Sorrento, DL. Neurosensory testing of the medial calcaneal and medial plantar nerves in patients with plantar heel pain. J Foot Ankle Surg 42:173–177, 2003.
11. Oztuna V, Ozge A, Eskandari MM, Colak M, Gölpinar A, Kuyurtar F. Nerve entrapment in painful heel syndrome. Foot Ankle Int 23:208–211, 2002.
12. Barrett SL. A guide to neurogenic etiologies of heel pain. Podiatry Today Nov:36–42, 2005.
13. Solitto RJ, Plotkin EL, Klein PG, Mullin P. Early clinical results of the use of radio frequency lesioning in the treatment of plantar fasciitis. J Foot Ankle Surg 36:215–219, 1997.
14. Migues A, Velan O, Solari G, Pace G, Slullitel G, Araujo SA. Osteoid osteoma of the calcaneus: percutaneous radiofrequency ablation. J Foot Ankle Surg 44:469–472, 2005.
15. Cozzarelli J. How sensory nerve conduction threshold evaluations can facilitate early detection and improved outcomes. Podiatry Today May:58–61, 2000.
16. Ro LS, Chen ST, Tang LM, Hsu WC, Chang HS, Huang CC. Current perception threshold testing in Fabry's disease. Muscle Nerve 22: 1531–1537, 1999.
17. Kanamori A, Tanaka K, Umezawa S, Matoba K, Fujita Y, Iizuka T, Yajima Y. Current perception threshold in evaluating diabetic neuropathy. J Japanese Diabet Soc 8:711–719, 1997.
18. Brown BA. Internal neurolysis in traumatic peripheral nerve lesions in continuity. Surg Clin North Am 52:1167–1175, 1972.
19. Grimes DW, Garner RW. Medial calcaneal neurotomy for painful heel spurs: a preliminary report. Orthop Rev 7:57–58, 1978.
20. Dellon AL, Kim J, Spaulding CM. Variations in the origin of the medial calcaneal nerve. J Am Podiatr Med Assoc 922:97–101, 2002.