PAN METATARSAL HEAD RESECTION/CAUSALGIA

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Severe lesser metatarsalgia and disabling forefoot pain is often reported in the presence of only minimal structural malalignment at the metatarsophalangeal joints. Often a nerve entrapment or causalgia syndrome is the source of the pain. Malay and McGlamry described a variety of endogenous and exogenous factors that may result in peripheral nerve entrapment (1)(Table 1).

If occurring in an area where motion is required or where an increased weight-bearing load is demanded, i.e., the lesser metatarsophalangeal joints and ball of the foot, nerve insults can be quite debilitating and often times require aggressive surgical intervention. In this chapter, we describe a variety of neuropathic scenarios as they relate to painful forefoot symptomatology and through case presentations show how pan metatarsal head resections can be effective treatment.

Prior to discussing the various types of nerve insult that may occur, a brief definition and review of the nerve injury classification scheme as presented by Seddon is in order (2). Though not an all inclusive system, the large majority of traumatic nerve disorders can be classified into one or a combination of three broad categories: neurotmesis, axonotmesis, and neuropraxia.

Neuropraxia is a term that refers to a local conduction block with preserved continuity of axons and preserved excitability of nerve structures as well as muscle tissues distal to the lesion. Symptoms will include motor paralysis and mild sensory stimulation. These lesions are due to local myelin damage induced by some form of mechanical pressure. Symptoms of neuropraxia normally peak within the first 2 weeks and remyelinization is usually complete by 6 weeks corresponding to complete resolution and restoration of normal sensation. Applicable examples of this phenomenon in the surgical profession include tourniquet and retraction neuropraxia.

Axonotmesis refers to a lesion, severe compression or stretching for example, that results in a loss of axonal continuity at the level of injury without insult to the endoneurial tubes. Therefore, in these cases the damaged axons will degenerate but the prognosis for restoration is good due to the intact connective tissue stroma surrounding the nerve. This will allow axonal regeneration to occur without misdirection at the site of injury.

Neurotmesis describes an injury pattern that not only involves axon and myelin sheath damage, but also includes some or all of the remaining elements of the nerve trunk including endoneurial tubes, perineurium, and epineurium. This lesion usually represents a complete severance of the nerve trunk with poor prognosis for spontaneous regeneration. This is the most severe and catastrophic of the peripheral nerve injuries and carries the poorest prognosis for successful recovery.

When applying the above definitions to the foot there are essentially three pathologic processes that may occur independently or in combination to produce severe and oftentimes disabling forefoot symptomatology.

The **first pathologic process** includes nerve, with or without loss of continuity, entrapped within scar tissue and subjected to direct compressive or ischemic forces. The **second process** involves a painful nerve entrapment resulting in a traction or tethering phenomenon. The third process stems from a loss of protective soft tissue bed, i.e., plantar fat pad, and leaves the nerve susceptible to the direct compressive forces of weightbearing. Oftentimes this **third process** involves elements of entrapment and ischemia as well as providing a tether for the nerve.

When nerve tissue is disrupted a unique inflammatory process results. As the axons are transected whether partially or in total, the stumps will separate in an amount determined by the extent and type of damage. The gap will be filled with hematoma, granulation tissue, and edema which can induce a secondary compression injury on adjacent intact fasiculi when present. There will be signs of degeneration and regeneration seen on both sides of the injury site.

Though Wallerian degeneration is classically described in reference to the degenerative changes seen in the distal stump, there will be similar processes occurring proximally. Within several days, conductivity will be lost as the axons and if present the myelin sheaths disintegrate. There is also great cellular proliferation at

Table 1

Etiology of Peripheral Nerve Entrapment

Endogenous

I. Congenital
   A. Anomalous development
   B. Overuse (stress anatomy fatigue)

II. Neoplastic

III. Metabolic

Exogenous

I. Traumatic
   A. Laceration (section)
   B. Blunt injury (neuropraxia)
   C. Traction

II. Iatrogenic
   A. Surgical technique
      1. Incision planning
      2. Dissection
      3. Hemostasis
      4. Nerve handling
      5. Wound closure
   B. Injection injury
   C. Tourniquet compression
   D. Circular bandages, casts
   E. Surgical positioning
   F. Traction
      1. Closed reduction
      2. Manipulation under anesthesia

III. Infectious
   A. Local abscess
   B. Post-inflammatory fibrosis

both ends with production of thick collagen and connective tissue scar formation. Axonal disruption almost always results in some type of neuroma formation. Fortunately regenerative effects begin almost immediately.

New axon sprouting is noted proximally at approximately one week (3). If appropriate endoneurial tissue is not present distally to guide the regenerating axons, immature axon branching will elongate and proliferate in an unorganized and aberrant fashion. Depending on the outcome of the above events and on the condition of the surrounding soft tissue bed a painful nerve entrapment is a very real possibility.

It is now quite easy to appreciate how a healing nerve with its unpredictable axon branching as described above can become incarcerated within its own as well as surrounding scar tissue. The nerve is then vulnerable to ischemic and compression forces often times producing persistent, painful paresthesias. If the regenerated nerve endings are superficial in nature, there is a good chance of developing adhesions to the overlying dermis producing a tethering effect. As the adhered skin is moved and stretched, the nerve is put on traction producing extremely painful sensory stimulation. This same principle applies to the nerve that has adhered to tendon or capsule or bone and is put under painful traction as motion occurs. When this situation occurs in conjunction with contractures at the lesser metatarsophalangeal joints, a disabling limitus condition may result. In such circumstances normal toe off causes traction on the nerve and a causalgia or chronic pain syndrom may result.

A third pathological scenario results when the nerve has lost its protective soft tissue bed, exemplified by

atrophy or iatrogenic loss of the plantar fat pad beneath the metatarsal heads. When this occurs, the sensory end receptors are constantly subjected to the direct compressive forces of weightbearing producing persistent, painful stimulation. Or if the nerve endings are entrapped in the scar tissue that frequently surrounds iatrogenic loss of fat padding there may be a further element of traction introduced.

Such patients often present with no gross structural abnormalities. Just as frequently one sees such syndromes associated with obvious iatrogenic or traumatically induced deformities. When the pain and disability become severe and conservative measures have been exhausted, aggressive surgical treatment should be considered. Extensive forefoot arthroplasty, including pan metatarsal head resection and appropriate digital repair has proved to be a successful treatment regimen.

There is agreement that it is best to avoid surgery in the presence of causalgia or reflex sympathetic dystrophy. But if an entrapped or tethered nerve is producing a constant flood of noxious stimulae it may be impossible to effectively treat without surgically relieving the entrapment.

Considering the principles behind the pan metatarsal head resection, its success is easily explained. By shortening the metatarsals we accomplish several changes. First, the normal metatarsal parabola is restored to a more proximal location where a more suitable plantar pad may be located. Second, resection of bone will decrease the distance the nerve and vascular structures have to travel, therefore taking tension off nerve fibers and also relaxing blood vessels. This frequently results in improved function of both nerve and blood vessels. Finally, the procedure allows for relaxation of the surrounding soft tissues. This will allow relocation of malaligned metatarsophalangeal joints taking the retrograde pressure off the metatarsal heads. By providing some slack in the nerve one often relieves existing traction or tethering.

Through a series of case presentations, we will demonstrate some of the above principles as they apply to the treatment of disabling forefoot symptomatology associated with nerve entrapment syndromes.

CASE HISTORY #1

A 46 year old male presented to the Podiatry Institute with a complaint of severe burning pain over the plantar aspect of the right forefoot. He had undergone neuroma surgery several years previously which was unsuccessful. Revisional surgery had then been done six weeks later through a plantar approach. It included a plantar attempt at neurectomy and excision of plantar soft tissues including much of the fat pad beneath metatarsal heads two and three.

The patient subsequently developed functional hallux limitus as well as structural lesser metatarsophalangeal joint limitus. The plantar soft tissues were adherent to the under side of the second and third metatarsophalangeal joints, and he experienced constant burning pain throughout the forefoot. The pain in the metatarsophalangeal joint area was so severe as to result in constant grasping with the toes to protect the metatarsal heads, further contributing to the metatarsophalangeal joint limitus. Pain was present at rest but was aggravated by standing and walking. Walking without shoes became impossible. The patient received some limited relief by wearing a pair of molded soft orthoses and a molded polyurethane slit crest with a plantar flap.

Upon presentation, the patient exhibited a very prominent antalgic limp on the right extremity. Initial inspection revealed no gross deformities on either extremity (Fig. 1A). Observation of the plantar aspect of the right foot revealed an obvious deficiency of the fat pad beneath metatarsal heads two and three (Fig. 1B). The protective pads beneath metatarsals one and five were present and normal. Examination of the lesser metatarsophalangeal joints revealed significant paresthesia and dyesthesia over the plantar aspect of metatarsal heads two, three, and four upon palpation. Pain radiated proximally to the level of the midtarsal joint. Motion at the metatarsophalangeal joints two, three, and four was significantly limited and produced a severe amount of discomfort.

Evaluation of the first ray exhibited a mild elevatus deformity with a painful limitation of motion at the metatarsophalangeal joint. The remainder of the podiatric examination was essentially within normal limits. Initial radiographic examination was negative for any gross structural abnormalities. There were some mild degenerative changes noted at the base of the proximal phalanx of the left fourth digit as well as a generalized osteopenia throughout the left foot (Fig. 1C).

Diagnoses

- loss of plantar fat pad with adherence of plantar skin to flexor plates
- adherence of plantar nerve stumps to plantar tissues with resultant traction neuropathy
- hallux limitus, probably resulting from protective muscular splinting
- lesser metatarsophalangeal joint limitus, due to plantar pad loss and adherence of plantar skin to flexor plates

Fig. 1. A. Dorsal view of foot prior to pan metatarsal head resection shows no gross deformities.

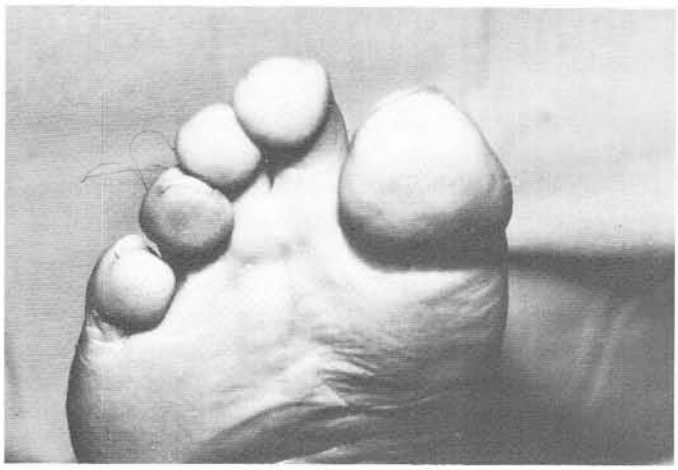

Fig. 1. B. Plantar view of right foot preoperatively revealing gross deficiency of plantar fat pad beneath metatarsal heads two and three.

Fig. 1. C. Preoperative radiographs were negative for any structural abnormalities with exception of mild degenerative changes along medial aspect of base of fourth proximal phalanx.

poorly vascularized bed for nerve passage due to loss of fat padding

The patient was made aware of rationale for surgery that was recommended. He was also made aware of the possibility of further surgery being necessary for specific plantar nerves that might not be relieved by the initial surgery. He was, in fact treated conservatively for more than three years before mutually agreeing that surgery was the only potential for improvement.

The patient was scheduled for reconstructive right foot surgery. The surgery included:

pan metatarsal head resection
first metatarsophalangeal joint implant arthroplasty

Surgery was performed through five dorsal longitudinal incisions (Fig. 1D). Through the medial incision an implant arthroplasty was performed using a Swanson total first metatarsophalangeal joint hinge implant. The lesser metatarsophalangeal joints were exposed through four separate longitudinal incisions centered over the joints. The incisions were kept as far distally over the joints as practical so as to minimize the length of each soft tissue island. Metatarsal heads two, three, four, and five were resected with care being taken to maintain a normal metatarsal parabola (length pattern 2,1,3,4,5). A .045 inch Kirschner wire (K-wire) was driven from within the metatarsophalangeal joint distally out the end of the digit and then retrograded into the metatarsal. Care was taken to maintain adequate space between the metatarsal stumps and their respective digits.

During stabilization of the fourth digit on the metatarsal a significant amount of flexion deformity was encountered at the proximal interphalangeal joint due to severe adhesions. This necessitated extending the skin incision distally along the dorsal aspect of the fourth digit and performing a soft tissue release at the interphalangeal joint. The K-wire was then introduced without complication. Closure was performed by anatomical tissue layers.

A dry, sterile dressing change was performed on the third postoperative day revealing all wound sites well coapted with minimal edema and peri-incisional erythema. Postoperative radiographs revealed excellent pin placement across the metatarsophalangeal joints and into the metatarsal shafts (Fig. 1E). The patient was discharged on the fourth postoperative day, full weightbearing bilaterally with a Darco Trauma shoe on the right foot. The shoe was padded with one-half inch felt extending from the heel to the metatarsal sulcus to prevent the wires from bending upon weightbearing (Fig. 1F).

Fig. 1. D. Use of five dorsal linear incisions necessitates care in limiting proximal excursion of three middle incisions. More proximal extension would create longer peninsulas of tissue between incisions and compromise blood supply.

Fig. 1. E. Postoperative radiographs show excellent pin placement and maintenance of normal metatarsal parabola.

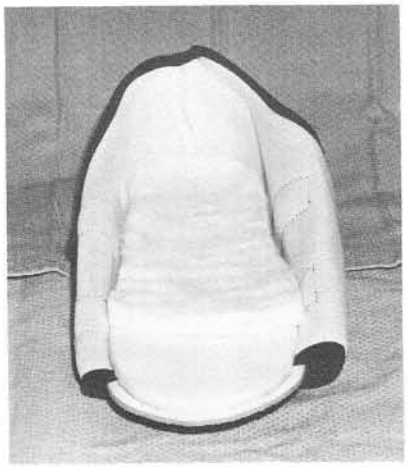

Fig. 1. F. Postoperative Darco trauma shoe with one-half inch felt. Padding runs from heel to metatarsal sulcus and serves to prevent pin bending upon weightbearing.

Fig. 1. G. Follow-up appearance one year postoperatively.

At discharge the patient's pain was greatly improved. Once the Kirschner wires were removed six weeks after surgery the patient was placed in a full length accommodative orthotic device.

Followup one year later revealed maintenance of the excellent alignment at the metatarsophalangeal joints (Figs. 1G). The patient reported walking on a soft track four times a week for two and one-half miles at a time. He also is able to walk barefoot around the house which he could not do preoperatively. He does still experience some pain when walking on hard surfaces but relates a dramatic improvement.

CASE HISTORY #2

A 69 year old female presented to Doctors Hospital on April 28, 1988 with complaint of multiple, painful left foot deformities. Her chief complaints were two. The first was pain over the dorsal aspect of the second metatarsal interspace. The second major complaint involved burning pain over the plantar aspect of the ball of the foot. She best described the discomfort as a "pulling" or "gnawing" sensation that is greatly exaggerated by even minimal periods of weightbearing. She reported having had multiple foot surgeries bilaterally over the past 40 years including four neuroma surgeries on the left ex-

tremity in the last four years. Conservative treatment measures had consisted of padding, strappings, shoe modifications, and local injection therapy with minimal relief of painful symptomatology.

Upon presentation, the patient displayed a mild adductovarus relationship to digits two, three, four, and five bilaterally (Fig. 2A). The plantar fat pad covering the metatarsal heads of the left foot was thinned and adherent to the underlying flexor plates. The range of motion at the lesser metatarsophalangeal joints on both feet was restricted with exception of the left second and third. The third digit was essentially flail while the second digit was extremely hyperesthetic to even the lightest touch. Motion at the second metatarsophalangeal joint was extremely painful and could really not be adequately examined. Other significant findings in the lower extremity examination included a generalized decrease in the epicritic sensation over all lesser digits as well as a decrease in active plantarflexion and dorsiflexion at the lesser metatarsophalangeal joints bilaterally.

Both great toe joints also exhibited a decrease in flexor strength and a floating hallux. There was no hypertrophic scar formation noted. However, the area over the dorsal aspect of the second interspace did have a moderate amount of palpable fibrosis. Diffuse tyloma formation was noted submetatarsal one and two on the right foot and one, three, and five on the left foot. The vascular status to both feet and all digits was within normal limits. Gait evaluation revealed an antalgic limp to the left extremity with the majority of weightbearing borne on lateral border of the foot.

Radiographic evaluation revealed signs of multiple, bilateral foot surgeries, including Keller procedures and lesser digit stabilizations. Residual deformities were present on the left foot including failed arthrodesis sites on digits two and three as well as loss of joint space at the first and second metatarsophalangeal joints (Fig. 2B).

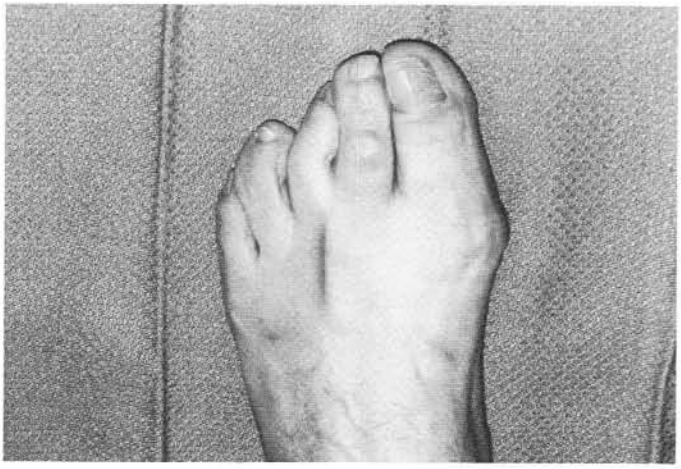

Fig. 2. A. Preoperative anteroposterior view demonstrates mild adductovarus relationships to lesser digits.

Fig. 2. B. Preoperative radiographs revealing evidence of multiple left foot surgeries. Residual deformities include failed arthrodesis sites on digits two and three and loss of joint space at first and second metatarsophalangeal joints.

Diagnosis

multiple plantar traction neuropathies due to extensive scarring and adherence of nerve stump neuromas to joint related structures (the extensive scarring throughout the forefoot had converted the intermetatarsal tunnels into dense collagenized tissue)
dorsal sensory nerve entrapment dorsolateral second metatarsophalangeal joint
hallux instability
lesser metatarsophalangeal joint limitus

Reconstructive forefoot surgery was scheduled on the left foot. It was obvious that extensive soft tissue relaxation would be required to effect any substantial improvement in symptoms.

Surgical Procedures

resection arthroplasty first metatarsophalangeal joint with Swanson total first metatarsophalangeal joint implant.
pan metatarsal head resection, two through five
end to end proximal interphalangeal joint arthrodesis digits two, three, and four.

Fig. 2. C. Postoperative radiographs reveal good pin placement across metatarsal shafts. Normal metatarsal length pattern is established with maintenance of adequate joint space including first metatarsophalangeal joint implant spacer.

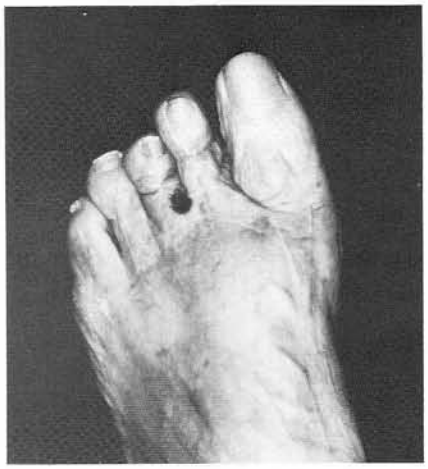

Fig. 2. D. Clinical appearance 6 months following surgery.

arthroplasty PIPJ fifth digit.
lysis of entrapped nerve dorsum sensory nerve

With the patient under general anesthesia and a thigh tourniquet a five incisional approach provided access for the above procedures. All incisions were opened at once so that the length pattern of the metatarsal resections could be effectively judged. The incisions over the lesser digits were begun at the level of the interphalangeal joints and continued proximally to the level of the metatarsophalangeal joint where they were curved slightly laterally. Care was taken to avoid extending too far proximally since this would provide for longer peninsulas of tissue between the incisions and could compromise blood supply.

In performing pan metatarsal head resections, attention was paid to maintain a normal metatarsal parabola. The second metatarsal was maintained longest, followed by the first, third, fourth and fifth respectively. Arthrodesis at the proximal interphalangeal joints of digits two, three, and four was maintained with a .045 K-wire driven distally out the end of the toe and then retrograded across the metatarsophalangeal joints. The arthroplasty site at the proximal interphalangeal joint of the fifth toe was also maintained with a .045 K-wire.

A sterile dressing change was performed on the third postoperative day. All incisions were seen to be well coapted with mild peri-incisional erythema present. The neurovascular status to all digits was within normal limits. Postoperative radiographs revealed excellent position of the digits on the newly constructed metatarsal parabola with good pin placement in the metatarsal shafts (Fig. 2C).

On the fourth postoperative day, the patient was discharged fully weightbearing bilaterally with a Darco surgical shoe on the left foot padded as previously described. She reported major though incomplete relief of neuritic pain in the left foot at discharge.

The patient again presented to Doctors Hospital six months later with continued burning pain over the dorsal aspect of the left second interspace. Clinical examination revealed excellent maintenance of rectus digital alignment (Fig. 2D). The lesser metatarsophalangeal joints exhibited a full range of motion. The only complaint was the severe burning pain at the base of the second web space. Plantar pain was now absent. The degree of pain over the second interspace and into the second digit was consistent with an entrapment syndrome. Placing the second toe in plantarflexion greatly exaggerated the sharp burning pain. A 1/2 cc 17 lidocaine block of the sensory nerve to the second interspace provided prompt and complete relief.

The patient was taken to the operating room where exploratory surgery was performed in the painful interspace. Using a three cm. linear incision over the second metatarsal interspace, dissection revealed a dorsal cutaneous nerve that was branching into very dense scar tissue. The nerve was dissected free of the scar tissue and excised.

The patient had an uneventful postoperative course and was discharged on the third postoperative day. She reported a comfortable convalescence for six weeks.

Some two months after neurectomy the patient reported a sudden recurrence of stump pain in the involved sensory nerve. It is possible that a new stump

neuroma has developed. As of this writing the outcome is uncertain. This points to a little understood adage that patients who have nerve entrapments or neuromas tend to be susceptible to other entrapments or neuromas, a neuromatous diathesis.

CASE HISTORY #3

A 46 year old female was referred to THE PODIATRY INSTITUTE complaining of severe right foot pain and instability. The pain was concentrated at the ball of the foot and described as "burning" in nature. The pain and edema were exaggerated with weightbearing. Pain was also exaggerated with dorsiflexion of the toes or with pronation of the rearfoot.

Pain had been present since the first of several foot surgeries three years previous, but had become increasingly severe with each attempt at surgical correction. She reported a total of five foot surgeries, all involving bone that had left her with a disabling array of forefoot deformities including structural defects as well as secondary traction neuropathy syndromes. Three months prior to admission, she began developing diffuse ankle and subtalar joint discomfort with pain also radiating from posterior medial malleolus into the arch of the foot. This appeared most likely secondary to severe pronation caused by iatrogenic structural derangement of the medial forefoot. As a result of pain she would not allow her foot flat to the ground.

Upon presentation the patient exhibited an antalgic limp on the right extremity with an inordinate amount of weight being borne under the lateral three metatarsals. Initial inspection revealed a floating right hallux as well as severe forefoot supinatus deformity (Figs. 3A & B). The abnormal structural alignment related to collapse of the medial half of the foot as a result of the first and second metatarsals being grossly unstable and in an elevated position. Range of motion examination revealed severely painful lesser metatarsophalangeal joint limitus deformity, most severe on the second but present to a lesser extent on the third, fourth, and fifth. Other significant findings in the clinical examination were a mild tarsal tunnel syndrome as well as the generalized ankle and subtalar joint pain described earlier. The tarsal tunnel symptoms appeared likely secondary to a traction phenomenon occurring because of distal tethering of the nerves in the forefoot combined with pronation that resulted from medial forefoot instability.

In stance evaluation, the right foot was held in an extreme amount of inversion with significant forefoot and rearfoot supinatus noted. The patient acknowledged that she held the foot in this position because it was painful when she allowed it to collapse into pronation. Ankle

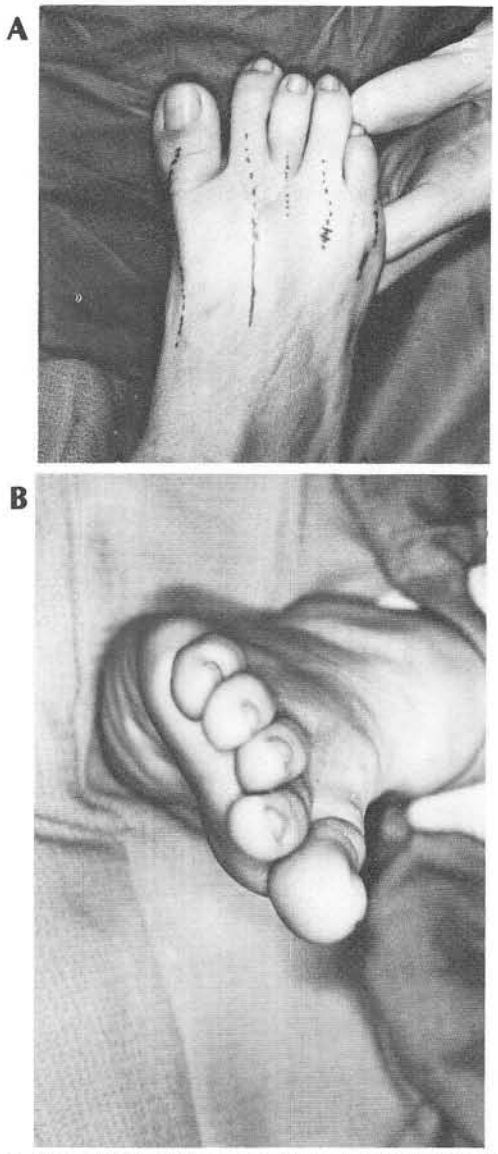

Fig. 3. A, B. Preoperative clinical appearance. Evidence of multiple right foot lesser digital malalignment. Severe forefoot supinatus is present secondary to collapse of medial aspect of foot where first and second metatarsals are in unstable elevated position.

and subtalar joint motion was of good quantity and quality. The straight leg raise test was negative. The remainder of the podiatric examination was unremarkable.

Radiographic evaluation revealed multiple nonunion sites on the right foot, including the first, second, and third metatarsals (Fig. 3C). Significant joint destruction and malalignment was noted at the first, second, and third metatarsophalangeal joints.

C

Fig. 3. C. Initial radiographs reveal multiple nonunion sites on right foot including first, second, and third metatarsals. Significant joint destruction is also noted at medial three metatarsophalangeal joints.

D

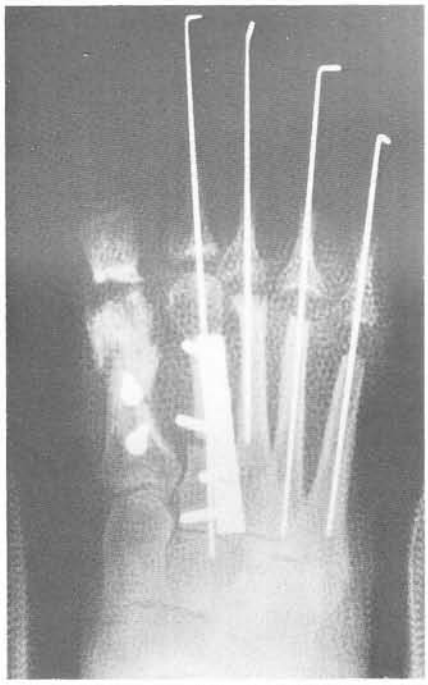

Fig. 3. D. Postoperative x-rays demonstrating re-establishment of normal metatarsal length pattern and repair of nonunion sites.

Diagnoses

non-union/pseudoarthrosis metatarsals first, second, third
medial forefoot instability, right foot
severe forefoot supinatus, right
tarsal tunnel syndrome secondary to unstable medial forefoot
severe lesser metatarsophalangeal joint limitus
traction neuropathy second, third, fourth intermetatarsal nerves

After thorough explanation of the planned procedures and outcomes as well as the potential risk and complications, the patient was scheduled for reconstructive foot surgery on the right extremity. It was felt that any effective surgery would need to:

restore weight bearing equality to the metatarsals
repair pseudoarthroses
shorten bone sufficiently to relieve soft tissue tension on the involved nerves
restore mobility to the metatarsophalangeal joints

Surgical Procedures

resection of pseudarthrosis and repair of nonunion with onlay bone graft, first metatarsal.
resection of pseudarthrosis with repair of nonunion, second metatarsal and appropriate shortening.
metatarsal head resection three, four, and five.

A five incisional approach was used beginning medially at the first ray. Through an 8 cm. incision the nonunion site at the first metatarsal was repaired with an autogenous onlay graft and two cortical screws. The nonunion site at the second metatarsal was then resected and the bone shortened and realigned. It was fixated using a .045 K-wire and a five hole plate with 2.7 mm screws. Care was taken to assure a good parabola with the other metatarsals. Using dorsal longitudinal incisions extending from the metatarsal necks to the proximal interphalangeal joints the metatarsal heads three, four, and five were resected at a level appropriate to maintain the length pattern in relation to the first and second. Proper joint positioning was maintained with .045 inch K-wire retrograded through the digit and into the metatarsal shaft. Closure was performed by anatomic layers.

On the third postoperative day a sterile dressing change was performed. All wounds were clean with margins well coapted. Aside from a mild amount of edema over the forefoot, the wound appearance was excellent. The pins maintained good position holding the digits in rectus alignment on their respective metatarsals. Postoperative radiographs indicated maintenance of an acceptable metatarsal parabola with all pins and hardware in good position (Fig. 3D). The patient was discharged on the fifth postoperative day in an above-knee cast and non weightbearing on the right extremity.

The patient again returned to the Podiatry Institute approximately three and one-half months later for removal of the hardware in right foot. Upon admission she was

wearing a below-knee bi-valved cast and continued to be non weightbearing on the right side. Clinical exam revealed the excellent alignment achieved earlier was still intact with the K-wire to the second ray still in place (Fig. 3E). Patient was prepared to resume weight bearing after allowing an additional four weeks for consolidation of bone grafts (Fig. 3F). She indicated that she had been free of pain throughout her convalescence, but, of course, she had been non weightbearing. The acid test comes when she resumes structural loading.

CASE HISTORY #4

A 66 year old female was referred to the Podiatry Institute complaining of recalcitrant nerve entrapment type pain in the left forefoot region. Pain was severe across entire ball of foot and also on the dorsolateral aspect of the foot. Weightbearing aggravated the pain, but severe burning was also present. Flexion or extension of the toes accentuated the plantar burning. Active dorsiflexion or passive plantarflexion of the fourth and fifth toes aggravated the dorsolateral pain. She also complained that touching the area on the dorsolateral aspect of the foot caused pain and tingling up to front of ankle and pain into the top of the fourth and fifth toes.

Years earlier she had undergone multiple metatarsal osteotomies and surgery of several digits. She had subsequently developed nerve entrapment pain in several interspaces. In the years that followed she had undergone multiple surgeries on the left foot for neuromas and entrapment syndromes. An amputation had been performed on the left third toe. A year earlier she had undergone surgery to remove five neuromas "with a laser."

Since her last operation approximately 1 year ago she related temporary relief of pain for about 3 months, but the pain had recurred and was much more severe than previously. The discomfort was located in two principle areas. One was on the dorsal aspect of the foot in the area of a thick scar from a prior tenotomy. Pressure on the scar produced a severe Tinel Sign with paresthesias up to the anterior ankle. She also described a second pain plantarly in the second,third, and fourth interspaces. This latter pain was "burning in nature" and seemed to involve all of the plantar aspect of the foot. Weightbearing aggravated the pain, but the burning was severe at night and interfered with the patient's rest.

Initial inspection revealed an amputated left third digit as well as multiple scars over the forefoot (Fig. 4A). Vasculitis was present in the distal half of the fourth toe which had been burned years earlier.

E

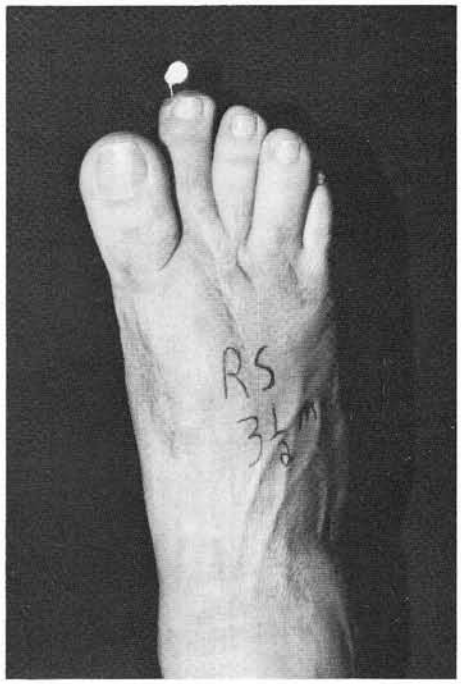

Fig. 3. E. Clinical appearance 3½ months postoperatively. Patient has been non weightbearing until this time.

F

Fig. 3. F. Postoperative radiograph 4 months following original surgery. Fixation removed from second metatarsal reveals good consolidation of graft. Metatarsal parabola is maintained.

Neurologic exam revealed epiritic sensation to be intact with the exception of the left fourth digit where it was decreased secondary to the previous burn injury. A positive Tinel's Sign was present upon percussion of the scar over the extensor tendon to the fifth toe. Pain and paresthesias radiated from the scar upward along

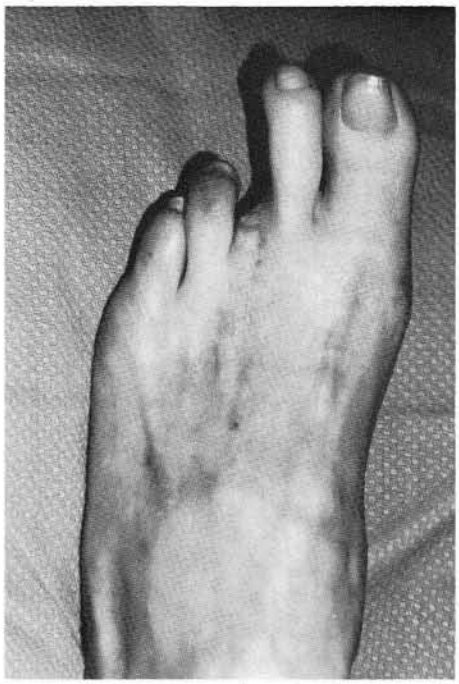

Fig. 4. A. Preoperative anteroposterior view demonstrating signs of multiple previous surgeries including an amputation of third digit.

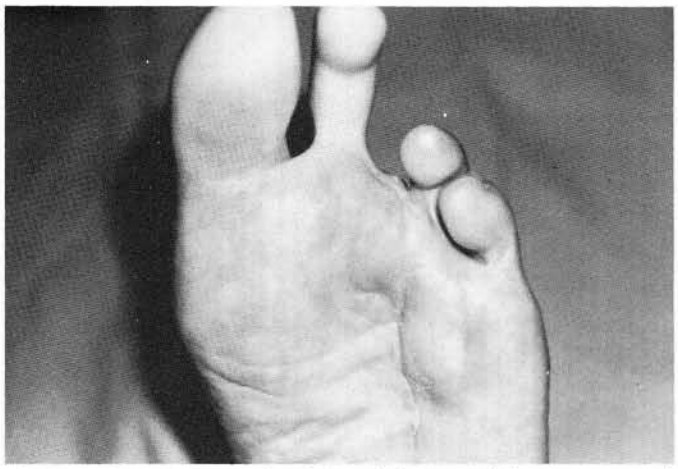

Fig. 4. B. Plantar view reveals obvious deficiency of plantar metatarsal fat pad.

the intermediate dorsal cutaneous nerve to the front of the ankle and distally into the fourth and fifth digits.

Range of motion exam revealed a painful limitus deformity at all the lesser metatarsophalangeal joints on the left foot. There was also an obvious deficiency of plantar fat pad sub metatarsals two, three, four, and five with pain upon direct pressure plantarly or with traction against the plantar skin (Fig. 4B).

Evaluation of preoperative radiographs revealed absence of the third digit to the level of the proximal half of the proximal phalanx (Fig. 4C). They were otherwise unremarkable for structural deformity, however a

Fig. 4. C. Preoperative radiograph showing severe narrowing of joint space at all metatarsophalangeal joints. Absence of third digit to level of midshaft proximal phalanx noted. Severe osteopenia is present in forefoot.

generalized osteoporotic appearance was noted over the forefoot. Severe narrowing of joint space was seen at all metatarsophalangeal joints.

Diagnoses

reflex sympathetic dystrophy due to nerve entrapment
loss of plantar fat pad with collagenization of plantar tissue layers
possible plantar stump neuromas
compromised plantar blood supply due to scarring and tissue traction
vasculitis left fourth toe
neuroma in continuity intermediate dorsal cutaneous nerve over extensor tendon scar dorsolateral aspect of foot
hallux limitus
lesser metatarsophalangeal joint limitus 2-5 left
osteoporosis left foot due to chronic pain syndrome and consequent disuse

In consultation with the patient and her husband it was explained that when a nerve is entrapped, compressed, under traction, or must pass through a bed of compromised soft tissue the nerve becomes chronically stimulated. Such stimulation results in the production of a constant stream of noxious stimuli into the proximal nerve. And while we would prefer to defer surgery in a patient with reflex sympathetic dystrophy or chronic pain syndrome, the fact is, rarely can one break the chronic pain cycle without first removing the painful

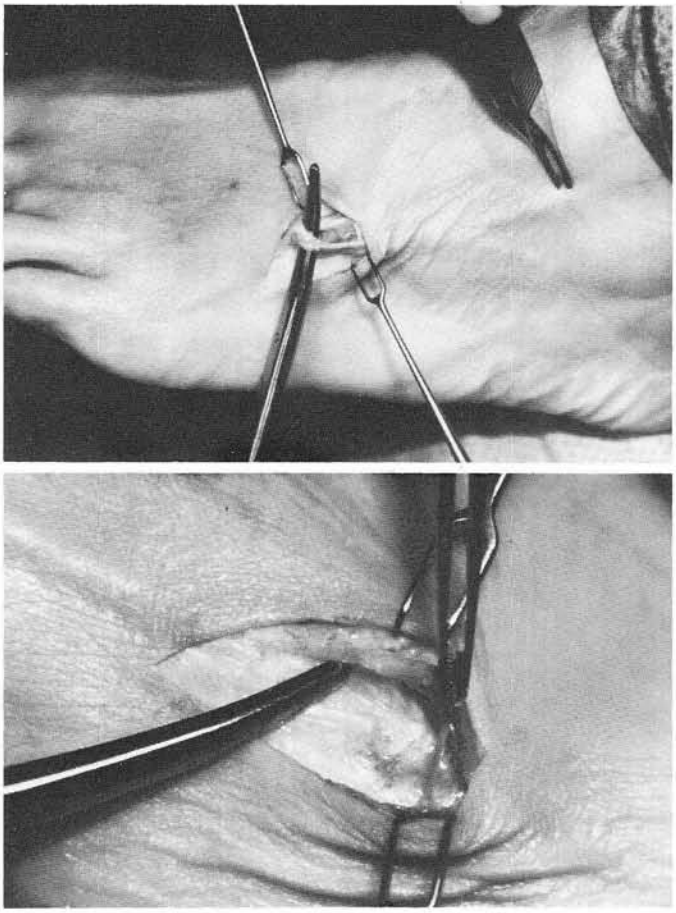

Fig. 4. D, E. Intraoperatively, intermediate dorsal cutaneous nerve was identified tethered to extensor tendon to fifth digit.

stimuli from the nerve. Surgery does carry an increased risk in such patients. But without surgery to interrupt the painful stimuli one is unlikely to succeed in any conservative treatment.

The patient and husband understood the rationale; since she had previously undergone multiple nerve blocks, transcutaneous electrical nerve stimulation, and various medical regimes without success.

The proposed surgery was explained as:

resecting bone to relieve soft tissue tension and traction on nerves and blood vessels
resecting bone to restore unrestricted range of motion
resecting bone to attempt to restore reasonably even weight distribution across the ball of the foot
resecting bone to place weightbearing ends of metatarsals on better plantar pad
neurectomy of the sensory branch of the intermediate dorsal cutaneous nerve at its point of incarceration

The patient was made aware that subsequent surgery might likely be necessary to deal with any residual points of pressure or hypersensitivity. In the event the plantar burning was unrelieved a plantar approach neurectomy of the involved spaces would be required.

Surgical Procedures

pan metatarsal head resection
total first metatarsophalangeal joint implant arthroplasty
resection of intermediate dorsal cutaneous nerve entrapment

The patient was taken to the operating room where the above procedures were performed under general anesthesia. Attention was first directed to dorsolateral aspect of the foot where the previous hypertrophic scar was excised with converging semi-elliptical incisions. A full thickness fibrotic scar involved skin, nerve, and tendon. The intermediate dorsal cutaneous nerve was identified and was found to be adhered to the extensor tendon to the fifth toe (Figs. 4D & E).

First metatarsophalangeal joint implant arthroplasty and pan metatarsal head resection were performed through five linear incisions as described earlier. Careful attention was again paid to assuring normal metatarsal length pattern. Excluding the third, the remaining lesser digits were held in rectus alignment with .045 K-wires. Closure was performed by anatomic layers.

Through the initial 3 postoperative days the sensation and circulatory status to the left fourth digit was questionable. A dressing change on day 3 revealed a trauma blister and dissecting hematoma over the distal aspect of the fourth digit (Fig. 4F). The pin was removed from the fourth digit on the fifth day and the toe immediately responded with return of good perfusion. With the vasculitis of the fourth toe there was serious question as to whether the toe would be lost. Subsequently the distal part of the toe was lost. Postoperative x-rays revealed a good metatarsal parabola and rectus alignment of remaining digits (Fig. 4G).

The patient's convalescence was difficult throughout. The distal pulp of the fourth toe was lost. While the dorsal nerve entrapment was relieved completely, the patient continued to experience plantar burning under the second metatarsal interspace. The burning continued at night and is aggravated by standing which is quite painful. As of this writing it is expected that additional plantar approach neurectomy will be required at approximately midmetatarsal level. This is not a surprising finding, and the patient was previously advised that surgery might be necessary to address any individual residual nerve entrapments.

This case points to the extreme complexity that is involved in treating the patient with chronic pain syndrome

F

Fig. 4. F. Dressing change on third day showing trauma blister and dissecting hematoma over fourth digit.

G

Fig. 4. G. Postoperative radiographs revealing re-established metatarsal parabola and rectus alignment of digits. Third digit has been completely removed.

related to nerve entrapment, stump neuroma, neuroma in continuity, compromised soft tissue bed and restricted motion with traction on soft tissue structures.

Though there are no easy answers, the principles of treatment must involve restoration of unrestricted motion, lysis or excision of entrapped nerves, excision of stump neuromas, resection of sufficient bone to place weightbearing on more proximal well preserved plantar pad, and transference of nerves into more vascularized and better padded layers.

Where there is loss of soft tissue pliability, loss of fat padding, or jamming of joints with traction on nerves, resection of bone is a mechanism to relieve soft tissue tension.

If there are residual areas of acute pain that can be localized to a particular nerve a subsequent surgery may excise that nerve stump or neuroma incontinuity.

Often such patients require follow-up with epidural or peripheral nerve blocks and with transcutaneous electrical nerve stimulation. The use of polyurethane molds day and night to minimize external stimulae to the area of involvement may be helpful. The treatment of patients with chronic pain due to nerve injury must be comprehensive. The best result is often less than full relief.

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