CHAPTER 15

Evaluation Of The Sub-Second Metatarsal/ Neuroma Syndrome

Jerry R. Maxwell, D.P.M.

Armando Carro, D.P.M.

Gordon Bean, D.P.M.

Brian Carpenter, B.S.

METATARSALGIA SYNDROME REVIEW

Metatarsalgia is a non-descript term which is used to describe many different painful conditions of the forefoot. Furthermore, pain in the lesser metatarsals can present in many different but distinguishable locations: dorsally, plantarly, at the metatarsophalangeal joint, or in the interspace.[1]

Metatarsalgia was first described as pain under the metatarsal heads by Durlacher in 1845.[2] Breithaupt (1855) described pain in the lesser metatarsals related to overuse (stress fractures).[3] This condition was again later described by Paugat in 1877, and by Deutchlaender in 1921.[3] T. G. Morton (1876) believed that pain under the metatarsals was due to an insufficient transverse metatarsal arch, causing a pinching of the nerve between the metatarsals.[4] T.G. Morton also stated that the painful affliction of the metatarsophalangeal articulation was due to an abnormal metatarsal parabola.[4] Freiberg was the first to describe osteochondritis of the lesser metatarsals in 1914.[5] Since its original description by Freiberg, many others have described it including Skiller in 1915, Kohler in 1923, and Panner in 1922.[6] Kohler agreed with T.G. Morton and believed that if considerable pressure is placed on the transverse metatarsal arch, the arch gives-way and excessive pressure is placed on the ends of the second, third, and fourth metatarsals.[7] Kohler also stated that the second metatarsal absorbs the most force of any of the metatarsals in weight bearing, as evidenced by being the most frequently involved in the swollen feet of soldiers.[7] Schuster (1927) disagreed with T.G. Morton and Kohler about the transverse metatarsal arch being responsible for metatarsalgia.[8] He believed that metatarsalgia was generally caused by a person wearing inappropriate shoes and by ambulation on inelastic surfaces.[8] D.J. Morton, in 1927, also wrote that those patients with an abnormally long second metatarsal will have an increased incidence of metatarsalgia in the second metatarsal.[9] A metatarsal that is long and falls outside the normal parabola will be plantarflexed and absorb an excessive amount of pressure under the metatarsal head.[10,11] Hertzler (1926) suggested that metatarsagia could be caused by inflammation of the joint, bursa, or transverse intermetatarsal ligament.[12] The intermetatarso-phalangeal bursa is dorsal to the transverse intermetatarsal ligament and is close to the neurovascular bundle. Thus, inflammation of this bursa could result in metatarsalgia.[13] The pain associated with a short metatarsal was first described by D.J. Morton in 1935.[14] In a study by Rodgers and Cavanagh (1988) using pressure plates, their results support Morton's theory that a shortened first metatarsal in relation to the second produces a significantly higher amount of pressure under the second metatarsal head, which can predispose this foot-type to problems.[15] Mulder (1951) agreed with T.G. Morton's theory that a neuroma is caused by a mechanical force of adjacent metatarsal heads pinching the nerve.[16] Nissen, also in 1951, stated his opinion that neuroma pain is secondary to ischemia of the nerve.[17] Albert (1990) stated that consideration must be given to soft tissue causes of lesser metatarsalgia such as verruca, porokeratosis, keloids, IPKs, plantar fibromatosis, and a displaced plantar fat pad.[18] Jimenez (1990) believed that the second and third metatarsals have a lesser amount of motion for accommodation of ground reactive forces than other metatarsals.[11] The second metatarsal is the most common metatarsal affected

in metatarsalgia, due to it being the most stress-absorbing of the lesser metatarsals.[6,7,10,19]

NEUROMA SYNDROME REVIEW

Clinical symptoms of the interdigital neuroma have been thoroughly described in the literature.[19,20] Surgical excision of neuromas have resulted in success rates usually above 80%. Harkless et al. reported on a long-term follow-up study of seventy surgically treated Morton's neuromas with a 93% subjective clinical success rate.[21] Greenfield et al. stated that surgical excision may yield early excellent results, but subsequent tenderness and pain may develop in the sole of the foot as a late result.[22]

Thomas G. Morton was the first cited in medical literature to describe this syndrome, and was confirmed by Thomas S.K. Morton.[23] A third Morton, Dudley J., described a symptom complex consisting of a short first metatarsal, hypermobility of the first ray, and a posterior displacement of the sesamoids termed "Morton's toe".[24] Cadaveric dissections performed by Siverhus et al. revealed plantarly directed branches of the common digital nerve, which may prevent retraction of the nerve after resection and could be a source of post-traumatic neuroma formation.[25] Graham et al. found that microscopically, there is a distinct relationship in nerve diameter and histological characteristics at the edge of the deep intermetatarsal ligament, suggesting a nerve entrapment syndrome.[26]

A maneuver for the clinical diagnosis of the interdigital neuroma, similar to the Lasegue test for sciatica, was described by Gauthier. This maneuver is performed with extension of the metatarsophalangeal and interphalangeal joint of all toes, followed by the presence of interspace pain. Flexion will lead to disappearance of the pain.[27]

Several long-term studies have revealed a high complication and failure rate following surgical excision of a Morton's neuroma. Beskin et al. reported on 39 recurrent interdigital neuromas that were re-operated on through both dorsal and plantar approaches. Their results showed that less than 50% of the patients gained complete relief, and 58% experienced persistent discomfort in certain shoes.[28] The dorsal approach resulted in a 21% failure rate and the plantar approach had a failure rate of 8%. Patients that have persistent symptomatology after neuroma excision frequently complain of a "fullness" or "lump" in the forefoot. Often, they describe the pain as a "stone bruise".

MATERIALS AND METHODS

From November 1990, to September 1993, twelve patients were treated for sub-second metatarsal-second intermetatarsal space neuroma syndrome. All patients were surgically treated with an osteotomy of the second metatarsal. The patients ranged in age from 22 to 68, with a mean of 36 years. One patient had a bilateral condition, thus a total of 13 osteotomies were performed. Seven of the patients had no prior surgical treatment. Five patients had previous failed second interspace neurectomies, two of which had two failed neurectomies prior to undergoing the proposed surgical procedure. All of the patients in this study also had excision of a possible stump neuroma or primary neurectomy in conjunction with the osteotomy, except for the patient who had bilateral symptoms. This patient only had the osteotomies performed. Postoperative follow-up ranged from 4 to 39 months, with a mean follow-up of 14 months. There were eight females and four males. In addition to the patient's subjective results in the postoperative period, objective assessment of pre- and postoperative radiographic comparison of the first metatarsal protrusion distance was included. This was performed by a single examiner, using standard radiographs taken with the patient fully weight-bearing in the angle and base of gait.

PROCEDURE

A dorsal curvilinear incision was made over the distal second metatarsal extending onto the metatarsophalangeal joint. The incision is deepened via sharp and blunt dissection with all vessels clamped and cauterized as necessary. Dissection is continued to the second interspace where the neuroma is identified and all branches transected as far distal as possible. The nerve trunk is then transected as far proximally as possible, thereby completely excising the neuroma tissue. Next, a linear periosteal-capsular incision is made over the distal second metatarsal shaft while the extensor tendon is retracted laterally. A freer elevator is used to reflect the periosteum from the metatarsal surgical neck. An osteotomy is then made from

dorsal-distal to proximal-plantar in a through-and-through fashion using an oscillating saw. The bone cut is made parallel to the weight bearing surface in order to achieve proximal linear shifting of the distal fragment, with only minimal elevation of the second metatarsal (Fig. 1). The distal fragment is shifted approximately 2 mm and then temporarily stabilized with a 0.045" K-wire. Intra-operative radiographs or fluoroscopy is used to confirm the desired alignment. Then, using a standard A-O technique, a 2.0 mm cortical screw is used for rigid internal fixation from dorsal-proximal to plantar-distal. The wound is irrigated and closed in anatomic layers. A dry, sterile compression dressing is applied. The patient is allowed to minimally ambulate in a postoperative shoe.

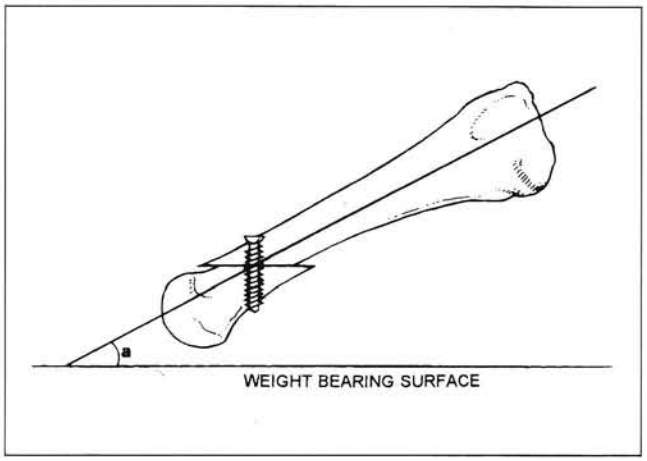

Figure 1. The osteotomy is performed parallel with the weight bearing surface and then shifted proximally 1- 3mm. The amount of shortening equals the distance that the distal fragment is shifted proximally. Only the width of the osteotomy cut (the width of the saw blade plus any postoperative bone resorption) will result in any elevation. a = angle of declination of the 2nd metatarsal.

RESULTS

The mean preoperative metatarsal protrusion distance was 3.9 mm, and postoperatively was 1.3 mm (Table 1). Therefore, an average of 2.6 mm of shortening was achieved. This corresponds with a 66.3% reduction in the average metatarsal protrusion distance.

Subjective and objective analysis demonstrated no transfer lesions secondary to the osteotomy. There was no evidence of non-union, delayed union, shifting of the osteotomy, or failure of the internal fixation devices. None of the patients have required additional surgery, and all patients are subjectively and objectively pain-free. One patient developed hypertrophic scar tissue and adhesions on the dorsum of the foot, and underwent cortisone injections with subsequent improvement.

Table 1

PREOPERATIVE AND POSTOPERATIVE FIRST METATARSAL PROTRUSION DISTANCE

Patient #	Preop Measurements	Postop Measurements
1	-1 mm	+1 mm
2	-9 mm	-4 mm
3	-7 mm	-2 mm
4	-5 mm	-2 mm
5	-2 mm	0 mm
6	0 mm	+2 mm
7	-2 mm	+2 mm
8	-4 mm	0 mm
9	-4 mm (R)	0 mm (R)
	-4 mm (L)	-1 mm (L)
10	-5 mm	0 mm
11	-4 mm	-1 mm
12	-4 mm	-1 mm

DISCUSSION

The authors propose that a certain percentage of patients meeting specific clinical and radiographic criteria are suitable candidates for this technique. The criteria includes a negative first metatarsal protrusion distance (i.e. a long second metatarsal or short first metatarsal, or focal pain beneath the second metatarsal and/or in the second intermetatarsal space). Clinically, these patients describe a "fullness", "stone bruise", "walking on a rock", and a tight feeling which is localized to the second metatarsophalangeal joint. Range of motion is typically pain free. Due to the high incidence of failure with second intermetatarsal space neurectomies, the authors are proposing that a closer evaluation of subjective and objective findings, including those just described, may reveal an underlying biomechanical causative factor that needs to be addressed in the treatment of the subsecond metatarsal-neuroma syndrome. The key additional biomechanical factor is a significant negative metatarsal protrusion distance, indicating either a short first ray or long second ray. Without addressing this factor, the clinician may only be

treating the patient's symptoms without attempting to identify and resolve the etiology. By not addressing the underlying etiology, the clinician and patient may be faced with a less than desirable long-term outcome. It is significant to note that none of the twelve patients had plantar tylomas, and that there was no attempt by the authors to elevate the metatarsal. By design, the osteotomy provides minimal elevation while providing decompression of the second metatarsophalangeal joint, and an improvement in the functional metatarsal protrusion distance.

CASE 1

A 22 year-old white female with a history of previous second intermetatarsal neuroma excision in 1991, and re-operation of a "stump" neuroma in 1992, presented to the authors' clinic. The chief complaint was burning pain between the second and third toes of the right foot with cramping pain and a feeling of "walking on a rock" beneath the second metatarsophalangeal joint. The patient underwent exhaustive conservative therapy, including cortisone injections in the second intermetatarsal space, without relief. The patient also received a series of sclerosing injections, however, remained symptomatic. Preoperative radiographs showed a negative first metatarsal protrusion distance of negative 1 mm (Fig. 2A).

The patient subsequently underwent surgical excision of a "stump" neuroma in the second intermetatarsal space along with a distal oblique osteotomy of the second metatarsal with cortical screw fixation of the right foot. Following the procedure, the patient was placed in a postoperative shoe, and had no postoperative complications. There were minimal subjective complaints of pain, and the sutures were removed in two weeks. At one month postoperative, the metatarsal protrusion distance was positive 1 mm (Fig. 2B). The remainder of the postoperative course was uneventful, and the patient was discharged pain-free in one year.

Figure 2A. Preoperative radiograph. Note the first metatarsal protrusion distance of negative 1 mm.

Figure 2B. Postoperative radiograph. The first metatarsal protrusion distance is now positive 1 mm.

CASE 2

A 26 year-old white female first presented in July 1991 with a painful right foot of two weeks duration. The patient described the pain as a burning sensation between the second and third toes, with occasional numbness. The patient related that with ambulation, it felt like there was a "stone bruise" in the ball of the right foot, as if she had been walking on a rock. The patient also denied any history of trauma to the right foot.

The patient's medical history was unremarkable. Physical examination revealed mild to moderate edema of the plantar-distal right foot. There was pain upon range of motion of the first, second, and third metatarsophalangeal joints, pain with palpation to the first and second intermetatarsal spaces, and pain with plantar palpation to metatarsals one and two. There was no ecchymosis or erythema present.

Radiographic evaluation revealed no obvious osseous pathology. The initial impression was metatarsophalangeal joint capsulitis, and the patient was treated with an oral anti-inflammatory medication.

The patient returned two weeks later with continued pain, this time localized to the second and third toes. There was moderate pain with palpation of the second intermetatarsal space and under the second metatarsal head. The previously symptomatic metatarsophalangeal joints were pain-free, and the clinical impression was narrowed to a second intermetatarsal space neuroma.

The patient was subsequently treated with a series of three steroid injections, and continued anti-inflammatory medication. As only temporary relief was afforded, surgical exploration was performed in September 1991. This consisted of excision of a painful second intermetatarsal space neuroma of the right foot.

Following surgery, the patient had complete relief of pain and was able to return to full activity two months postoperative. At approximately four to five months postoperative, the patient had a return of the original symptoms. The patient was evaluated and treated over the next several months with a combination of sclerosing agent injections, steroid injections, and a functional orthosis. This treatment provided only temporary and partial relief of pain.

In September 1992, a second surgery was discussed with the patient and performed. In reviewing the patient's preoperative radiographs, a metatarsal protrusion distance of negative 5 mm was noted (Fig. 3A). Therefore, a second surgery was performed which addressed the metatarsal protrusion distance as a contributing pathological factor, by performing an osteotomy, on the second metatarsal as previous described, as well as excising the "stump" neuroma.

Following surgery, the patient was kept non-weight bearing for two weeks, partial weight bearing for one week, and then progressed to full weight-bearing in a surgical shoe for three more weeks. The patient progressed to primary bone healing with a metatarsal protrusion distance of negative 2 mm (Fig. 3B). The patient has now been followed for fifteen months, and to date remains completely asymptomatic.

Figure 3A. Preoperative radiograph showing a negative 5 mm metatarsal protrusion distance.

Figure 3B. Postoperative radiograph. The first metatarsal protrusion distance is now negative 2 mm.

SUMMARY

The surgical technique outlined was performed on a select group of patients, all of whom were initially diagnosed with neuromas of the second intermetatarsal space using the classical signs and symptoms, but who were unresponsive to standard treatment methods. Upon further investigation, the negative metatarsal protrusion distance was noted and felt to be significantly contributory in the evaluation and treatment of the sub-second metatarsal neuroma syndrome. The clinical picture of a sub-second metatarsal neuroma syndrome is better evaluated and managed when one addresses the biomechanics of the second ray. The literature strongly supports that multiple neuroma excisions can lead to stump neuroma formation, which is associated with a high incidence of failure. Because of the characteristic subjective and objective findings in this group of patients, which include a "stone bruise" phenomenon in the area of the second metatarsal, the protrusion distance differential leads to a functionally long second metatarsal. The authors feel that this approach deals more effectively and directly with the etiology of this multifaceted symptom complex.

The authors recognize that there are certain inherent limitations in this retrospective study, and therefore are hoping to continue work in this area, with a prospective study to follow. One of the desired outcomes of this paper is to stimulate additional thought in the assessment of this challenging symptom complex, as well as to benefit future patients that may fit the proposed criteria for this procedure.

REFERENCES

1. Pack LG, Julien PH: Differential Diagnosis of Lesser Metatarsalgia. *Clin Podiatr Med Surg* 7(4), October 1990.
2. Durlacher L: *A Treatise on Corns, Bunions, the Disease of Nails and the General Management of Feet.* London, Simpkin, Marshall and Co, 1845:52.
3. Bogy LT, Fladger CB: Historic perspective of lesser metatarsalgia. *Clin Podiatr Med Surg* 7(4), October 1990.
4. Morton TG: A peculiar and painful affection of the fourth metatarsophalangeal articulation. *Am J Med Sci* 71:37-45, 1876.
5. Freiburg AH: Infraction of the second metatarsal bone. *Surg Gynecol Obstet* 14:191, 1914.
6. Beito SB, Lavery LA: Freiberg's disease and discoloration of the second metatarsophalangeal joint. *Clin Podiatr Med Surg* 7(4): October 1990.
7. Kohler A: Typical disease of the second metatarsophalangeal joint. *Am J Roengen* 10:705-710, Sept 1923.
8. Shuster OF: *Foot Orthopedics.* New York, GB Lyon, 1927.
9. Morton DJ: Metatarsus Atavicus: The identification of a distinctive foot disorder. *J Bone Joint Surg* 9:531, 1927.
10. Thompson FM, Hamilton WG: Problems of the second metatarsophalangeal joint. *Orthop* 10(1):83-89, 1987.
11. Jimenez AL, Martin DE, Phillips AJ: Lesser metatarsalgia evaluation and treatment. *Clin in Podiatr Med Surg* 7(4): Oct 1990.
12. Hertzler AE: Bursitides of the plantar surface of the foot. *Am J Surg* NS 1:117-126, 1926.
13. Bossey CJ, Cairney PC: The intermetatarsophalangeal bursa-Its significance in Morton's metatarsalgia. *J Bone Joint Surg* 62B(2): May 1980.
14. Morton DJ: *The Human Foot.* New York: Columbia University Press, 1935.
15. Rodgers MM, Cavanagh PR: Pressure distribution in Morton's foot structure. *Med Sci Sports Exerc* 21(1):23-28, 1989.
16. Mulder DJ: The causative mechanisms in Morton's metatarsalgia. *J Bone Joint Surg* (Br) 33B:94-95, 1951.
17. Nissen KI. The etiology of Morton's metatarsalgia. *J Bone Joint Surg* (Br) 33B:293-294, 1951.
18. Albert SF: Soft tissue causes of metatarsalgia. *Clin Podiatr Med Surg* 7(4), Oct 1990.
19. Helal B, Gibb P: Frieburg's diseases: a suggested pattern of management. *Foot Ankle* 8:94-102, 1987.
20. Betts LO: Morton's metatarsalgia: neuritis of the fourth digital nerve. *Med J Aust* 1:514-515, 1940.
21. Harkless LB, Odom R, Higgins K, Ballew KK, Keh R: Long-term followings of Morton's neuroma. *J Foot Surg* 31(1):93-95, 1992.
22. Greenfield J, Rea J, Lifeld FW: Morton's interdigital neuroma: indications for treatment by local injections vs. surgery. *Clin Orthop* 185:142-144, 1984.
23. Morton TG: A peculiar and painful affection of the fourth metatarsophalangeal articulation. *Am J Med Sci* 71:37-45, 1876.
24. Lassmann G: Morton's toe: clinical, light, and electron microscopic investigation of 133 cases. *Clin Orthop* 142:73-84, 1979.
25. Siverhus SW, Liwnloz BH, Amis JA; An anatomic basis for recurrence after Morton's neuroma excision. *Foot Ankle* 13(3):153156, 1992.
26. Graham CE, Johnson KA: The intermetatarsal nerve: A microscopic evaluation. *Foot Ankle* 2:150-152, 1981.
27. King LS: Note on the pathology of Morton's metatarsalgia. *Am J Clin Pathol* 16:124-128, 1946.
28. Beskin JL, Baxter DE: Recurrent pain following interdigital neurectomy-a plantar approach. *Foot Ankle* 9(1):34-39, 1988.

ADDITIONAL REFERENCES

Bickel WH, Dockery MB: Plantar neuromas, Morton's toe. *Surg Gynecol Obstet* 84:111-116, 1987.

Durlacker L: *Treatise on Corns, Bunions, the Disease of nails and the General Management of Feet.* London: Simpkin, Marshall and Co. 1845, p. 52.

Gauthier G: Thomas Morton's disease: A nerve entrapment syndrome. A new surgical technique. *Clin Orthop* 142:90-92, 1979.

Kopell HP, Thompson WAL: Peripheral entrapment neuropathies of the lower extremity. *N Engl J Med* 262:56-60, 1960.

Lassmann G: Morton's toe: clinical, light, and electron microscopic investigation of 133 cases. *Clin Orthop* 142:73-84, 1979.

Mann R, Reynolds JC: Interdigital neuroma: A critical clinical analysis. *Foot Ankle* 3:238-243, 1983.

Meachim G, Abberton MJ: Histological findings in Morton's metatarsalgia. *J Pathol* 103:125-141, 1952.

Suderland S, Bradley KC: The perineurium of peripheral nerves. *Anat Rec* 113:125-141, 1952.