CHAPTER 4

# LESSER METATARSAL SURGERY FOR THE TREATMENT OF CHRONIC INTRACTABLE PLANTAR KERATOSIS

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Intractable plantar keratosis (IPK) and discreet tylomas under the lesser metatarsal heads have long been a problem to both podiatric patients and physicians (Fig. 1). When conservative options have been exhausted, patients often hope for a surgical cure. The results of lesser metatarsal surgery, however, are often unpredictable and disappointing.

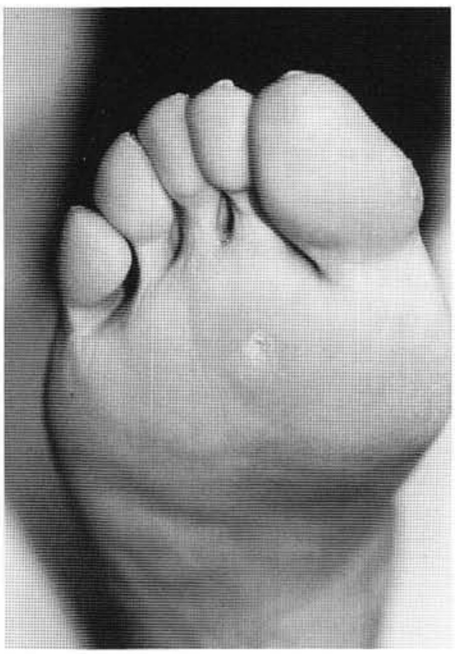

Figure 1. Clinical view of plantar intractable keratosis beneath the second metatarsal head.

## LITERATURE REVIEW

Lesser metatarsal osteotomies date back to 1916, when Meisenbach described a lesser metatarsal osteotomy to elevate the second, third, and fourth metatarsal heads to treat deep-seated calluses in what he referred to as the "rigid reversed anterior arch" where the second, third, and fourth metatarsophalangeal joints (MPJs) were plantarflexed relative to the first and fifth MPJs. He described a complete, transverse, midshaft osteotomy without fixation.[1] In 1917, Davis reported that he removed a lesser metatarsal head to treat a plantar callous which he felt was secondary to a traumatically-induced enlarged metatarsal head.[2]

Mau, in 1940, suggested removing a bony wedge at the proximal end of the metatarsal shaft to attempt to reconstruct the parabola of the metatarsals.[3] In 1948, Dickson described removing a wedge-shaped area of the foot to include the "wart," toe and metatarsal bone. He failed to realize that these singular "warts" underlying bony prominences were probably IPKs. No histological specimens were reported on any of his twenty-five patients who all received total ray resections.[4]

In 1949, Borggrene[5] described how he removed a trapezoidal fragment from the metaphysis of the distal aspect of the metatarsal for this problem, while McKeever, in 1952 reported on a telescopic shortening osteotomy to relieve the metatarsal bone of stress imposed by weight bearing. This involved placing an osteotomy transversely at the distal portion of the metatarsal neck and then using a drill to "hollow out" the metatarsal head to the depth required to get the degree of necessary shortening.[6]

The plantar condylectomy was introduced by DuVries in 1953. DuVries excised twenty-three plantar condyles for intractable growths directly under the metatarsal heads using bone forceps. He related success in over 91% of his cases with no mention of complications or follow-up.[7]

Giannestras, in 1954, discussed the fact that "plantar warts" were a different entity than plantar keratosis and described a procedure to correct the latter. This involved a shortening osteotomy of the metatarsal shaft fixated with catgut suture. He reported a 90.5% success rate with two failures which were recurrences of the keratosis. Four years later, he modified the procedure to be a shortening osteotomy at the metatarsal base (instead of the shaft) in cancellous bone to allow for better healing. It is not clear why he modified the procedure since in his previous study he related 0% complications with respect to delayed healing. He continued to fixate with catgut suture, but also immobilized his patients in a cast for four weeks after surgery.[8]

In 1956, Billig discussed both plantar and dorsal approaches to removing the plantar condyles to treat "metatarsalgia."[9] In 1957, Anderson described excision of the "wart and its associated callous" with resection of the underlying bony prominence and resurfacing of the soft tissue defect with pedicled plantar skin to avoid scar formation. He recommended removing the hypertrophied metatarsal head and if necessary, the prominent lip of the proximal phalanx with any associated sesamoid bone.[10]

Also in 1957, Rutledge described removing the metatarsal head and distal shaft for "plantar corns." He related that the toe receded one-eighth to one-fourth an inch but "cosmetically, this is hardly noticeable." He planned a five-year follow-up which cannot be found in the literature.[11] In 1959, Kelikian took a more aggressive approach recommending resecting the distal one-third of the central metatarsal bones for relief of indolent plantar keratosis. He also advised syndactylizing the adjacent digits to prevent excessive retraction of the corresponding digit.[12]

DuVries, in 1965, described an arthroplasty and plantar condylectomy for IPKs under the lesser metatarsal heads. This procedure removed two millimeters of the articular cartilage as well as the entire plantar condyle.[13]

Thomas, in 1969, supported Meisenbach's approach and performed an almost complete osteotomy in the metatarsal neck. He used an osteotomy and manual pressure plantarly, thereby producing a greenstick fracture. Interestingly enough, he recommended that after completing the osteotomy on one metatarsal, another metatarsal head may feel prominent, and if so, to perform the same procedure on that corresponding metatarsal.[14]

In 1970, Addante described an "osteoclasis" type procedure where a bone cutter was used to produce an osteotomy in the metatarsal shaft in a diagonal fashion. The patient was allowed to bear weight to permit dorsal displacement of the distal fragment.[15] In 1971, Davidson reported on his non-stabilized metatarsal head osteotomy, essentially an osteoclasis procedure. He felt the exact amount and degree of elevation of the metatarsal head would be determined by weight bearing, like Addante, and that "nature" is used to place the metatarsal head in its weight-bearing position.[16] That same year, Sgarlato described removing wedges of bone from the base of the metatarsal (apex plantar) to dorsally migrate the distal aspect of the metatarsal relative to the proximal aspect.[17]

In 1973, Graver described a modification of Meisenbach's procedure for correction of IPKs. The modification was meant to eliminate transverse motion, thereby allowing motion only in the sagittal plane. He described a "V" osteotomy in the metaphysis with the apex proximal and lateral limbs distal. After manual manipulation, the patient was allowed to bear weight in a surgical shoe.[18]

Also in 1973, Jacoby described a "V" osteotomy with the apex distal in the surgical neck of the metatarsal for treatment of IPKs. He felt one advantage of this procedure was that it did not enter the joint, preventing postoperative limitation of joint motion and post-traumatic arthritis. His study of fifty patients with a six month follow-up revealed good results. No fixation was utilized, and he relied on rigid orthosis for postoperative biomechanical control.[19]

That same year, Reese discussed two surgical procedures for correction of IPKs. The first, was a partial metatarsal head osteotomy for long metatarsals or hypertrophied plantar condyles. The second, the "V" osteotomy (developed by Jacoby) for those deformities due to a long metatarsal or plantar declinated metatarsal. He also discussed the double "V" osteotomy where a second "V" is made proximal to the first for those deformities requiring metatarsal shortening. Although no statistics were presented, he stated his results were favorable.[20] Again that year, Wolf reported his own technique. He made a "V" shaped notch in the metatarsal shaft down to, but not including the metatarsal shaft and then used manual pressure to greenstick the fracture.[21]

In 1975, Sullivan described an osteotomy which started directly on the articular cartilage of the metatarsal head just distal to the dorsal transverse notch and angled the osteotomy dorso-distal to plantar-proximal. In this way, the osteotomy could move dorsally but have no movement in the transverse plane. No fixation was used and immediate weight bearing was allowed.[22] That same year, Helal described an oblique osteotomy in the distal half of the metatarsal shaft which was not fixated. Complications included infection, fibrous union and metatarsophalangeal stiffness.[23]

In 1983, Kuwada utilized a modified Suppan cartilaginous articulation preservation osteotomy combined with excision of the plantar lesion. Complications were reportedly few, but included recurrence of the lesion, and shortening and elevation of the corresponding toe.[24] Sclamberg also published an article that year, describing an inverted "V" osteotomy of the proximal metaphysis allowing removal of a dorsal wedge of bone to relieve painful plantar calluses. No fixation was recommended.[25] The following year, Berkun described a "tilt-up" osteotomy in the surgical neck without fixation to correct IPKs. He felt this was a superior procedure to others because it allowed the surgeon the ability to allow the amount of elevation necessary.[26]

In 1988, Pedowitz reported an 83% success rate using a distal oblique osteotomy. Again, his osteotomies were non-fixated and immediate weight bearing was allowed.[27]

In 1990, Spence described a proximal metatarsal segmental resection which involved resecting a 0.5 cm cylindrical segment of bone. The procedure was performed without fixation and no cast was recommended. Only 24% of the patients healed with bony union.[28] Also that year, Leventeen described an osteotomy similar to Wolf's, with the exception that the osteotomy was performed distally, as close to the metatarsal head as possible.[29]

In 1992, Cheng described an oblique osteotomy in the distal one-third of the bone, sliding the distal fragment dorsally with intramedullary pin fixation. His complications, although reportedly low, included malunion, remittent pain, and painful unresolved callus.[30]

In 1994, Malay reported that in many cases digital stabilization and MPJ relocation, in conjunction with metatarsal balance padding, could provide satisfactory alleviation of lesser metatarsalgia without the need for isolated metatarsal osteotomy.[31]

## ETIOLOGY

There are volumes of literature discussing various surgical procedures to correct lesser metatarsal deformities. Most, if not all, consider the etiology to be purely structural, and little information is documented on biomechanical considerations. A thorough understanding of the biomechanics of the lesser rays is essential to determining the underlying etiology of lesser metatarsal lesions.

The lesser metatarsophalangeal joints (MPJs) have two distinct axes of motion providing sagittal and transverse motion. One axis lies at the intersection of the frontal and transverse planes and is referred to as the dorsiflexion-plantarflexion axis. The second, the abduction-adduction axis, lies at the intersection of the sagittal and frontal planes. No inversion or eversion normally occurs within a digit. The exception to this is when a subluxation or dislocation of the MPJ occurs, you may get some rotation of a digit.[32]

The second and third metatarsals function together with their respective cuneiforms as rays. The fourth ray is the fourth metatarsal only. Each of these rays has only one axis of motion exhibiting pure plantarflexion-dorsiflexion and no other motion.[32]

In order to get more than 20 to 30 degrees of dorsiflexion at the lesser MPJs, the lesser rays must plantarflex. The plantar MPJ ligaments and the deep transverse intermetatarsal ligament function to allow the metatarsal heads to glide posteriorly as the rays become plantarflexed during propulsion. The transverse head of the adductor hallucis muscle, because of its insertion along the course of the transverse intermetatarsal ligament and other plantar ligaments, stabilizes the transverse intermetatarsal structures particularly during the propulsive period of the stance phase of gait.

Biomechanically induced conditions such as abnormal pronation, hypermobility of the first ray, digital contractures, fat pad abnormalities, and dislocated MPJs can all produce excessive pressure under the metatarsal heads, leading to a plantar lesion (Figs. 2A, 2B).[33] Some common biomechanical abnormalities that may cause plantar keratoses include compensated rearfoot and forefoot varus and equinus.[34]

Several structural deformities are also responsible for plantar lesions including enlarged metatarsal heads, prominent plantar condyles, an

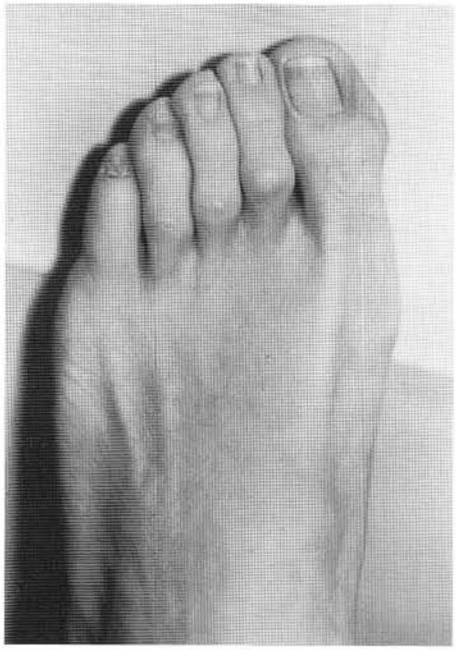

Figure 2A. Clinical view demonstrating contracted digits and mild hallux abductus

Figure 2B. Plantar view demonstrating diffuse tylomas sub-metatarsal two, resulting from the retrograde forces from digital deformities and hypermobile 1st ray.

abnormally long metatarsal (Fig. 3), a plantarflexed metatarsal, previous fracture (Figs. 4A, 4B), or previous surgical malalignment. Obviously, plantar lesions caused by a combination of biomechanical and structural defects are more challenging to treat. In either case, the underlying etiology must be identified in order to determine if a surgical option is available and whether or not postoperative orthotic control is indicated.

## CLINICAL AND RADIOGRAPHIC EVALUATION

The clinical evaluation should include a thorough biomechanical examination with gait analysis to identify any major forefoot or rearfoot deformities. The lesser metatarsal heads should be palpated with the subtalar joint in neutral position, and the midtarsal joint maximally pronated and locked. This can aid in identifying which metatarsals may be plantarflexed or dorsiflexed in relation to the adjacent metatarsal. The MPJs should be placed through their respective ranges of motion noting any crepitus or limitation of motion.

The corresponding digit needs to be evaluated. Digital contractures can produce a retrograde force on the metatarsal head, allowing it to

Figure 3. Radiograph demonstrating a long second metatarsal.

Figure 4A. Radiograph demonstrating shortening of the second metatarsal as a result of a stress fracture.

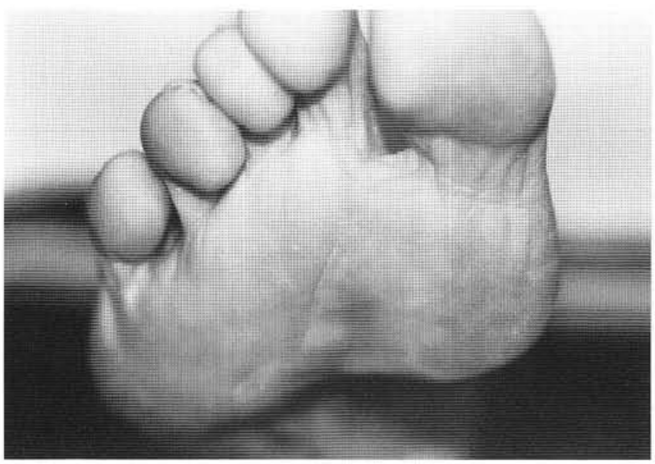

Figure 4B. Clinical view of same patient. Note the prominence of the adjacent metatarsal heads as a result of the stress fracture

function in a plantargrade position. An attempt should be made to manually reduce the digital contracture to see if this releases the plantargrade pressure on the metatarsal head. In these cases, the digital deformities may be the primary etiology for the lesion under the lesser metatarsal head and not the structural position of the lesser metatarsal head. Since many lesions under the lesser metatarsal heads result from first ray instability or hypermobility, this also needs to be critically evaluated. A pedobarograph, if available, is an excellent clinical adjunct to display pressure distribution beneath the weight bearing-surface of the foot, allowing quantitative measurements.[35]

Radiographs alone cannot be used to determine the etiology of lesser metatarsal lesions; however, they can be used to confirm clinical impressions. The radiographs must be taken in the angle and base of gait. Marking the lesion with a piece of wire can also be helpful in determining whether the lesion lies under a bony prominence.

In addition to assisting in identifying biomechanical and structural abnormalities of the foot, particular views can also aid in identifying characteristics of certain abnormalities necessary for determining the cause of the lesion. An anterior-posterior (AP) view can assist in evaluating the metatarsal parabola, size of the metatarsal heads, degenerative joint changes and the position of the digits in relation to the metatarsals. A lateral view demonstrates the sagittal position of the first metatarsal as well as the position of the digits relative to the metatarsals.

The axial view needs to be evaluated with caution. The device itself causes the more mobile first and fifth metatarsals to plantarflex the most, followed by the fourth, third, and second metatarsals. Therefore, the first and fifth metatarsals will appear to be the most plantar on this view and the second metatarsal to be the most dorsal. Since the axial view does not accurately project the lesser metatarsal heads in their proper weight-bearing alignment, it alone does not quantify the degree that the suspected metatarsal is plantarly or dorsally displaced. This view may further demonstrate the shape of the plantar condyles, shape of the metatarsal head and the soft tissue density beneath the metatarsal heads.[34]

## CONSERVATIVE AND SURGICAL TREATMENT

Conservative therapy such as a lower heel, balancing insoles, orthotics, and palliative care can be very beneficial for patients with lesser metatarsal lesions. Digital retainers can also be helpful in reducing the plantargrade pressure on the metatarsal head.

When conservative measures fail, surgical intervention may be necessary. It is important to determine the exact etiology of the deformity. In many cases this is where the first difficulty exists. The second difficulty is determining the exact amount of correction. If the metatarsal is too long, a shortening osteotomy is indicated. This can be achieved near the base, midshaft, or distally. If the head of the metatarsal is plantarflexed, an elevational osteotomy is indicated. For both the long and/or plantarflexed metatarsal, the best location based on anatomical considerations as well as surgical execution, is in the distal aspect of the metatarsal. Midshaft osteotomies have been known to produce a high incidence of delayed union or non-union as well as distal malalignment.[23,28] Proximal osteotomies are technically difficult, with less predictability as to the final position of the metatarsal head primarily because of the long lever arm between the osteotomy site and the metatarsal head.[28]

If any digital deformities are present, they should be reduced because they contribute to the final metatarsal head position, with or without concurrent osteotomy. This includes MPJ releases and reduction of MPJ deformities such as dislocations.

Fixation is a controversial issue. There are some osteotomies such as the distal "V" that are inherently more stable by design. The distal "V" osteotomy does not require joint dissection. It also preserves key ligaments such as the collateral and suspensory ligaments that gives more stability to the osteotomy and gives a more predictable result particularly when combined with fixation.[36] Many authors feel fixation is not necessary since weight bearing allows the metatarsal head to elevate to its "functional" or "proper" position.[16,22,23,28] If this were true, the incidence of transfer lesions should be negligible. Although it is difficult to predict how much to elevate or shorten a metatarsal and attempts have been made to do so by other authors, the best answer lies in the results of the clinical and radiographic evaluation. Fixation can be used to maintain the surgical alignment. It can help to prevent the pain that can occur from the excessive bone callus that results when non-fixated osteotomies heal. This is often palpable dorsally and can cause synovitis, capsulitis and chronic edema. This can take one to two years to resolve.[37] Immobilization with or without fixation is another adjunct that can be used postoperatively to assist in the success of the bone healing.

In certain cases, it may be advisable to excise the painful lesion at the time of the surgical correction of the lesser metatarsal.[24] Postoperative functional orthotics are useful to prevent or control transfer lesions or metatarsalgia due to changes in the weight bearing status of the metatarsal head.

Complications following lesser metatarsal surgery are high, and include metatarsalgia, transfer lesions, delayed union and non-union, painful bone callus, recurrence of the lesion, MPJ arthritis, digital elevation and/or instability, malalignment, and joint pain as well as less specific problems like infection, wound dehiscence, and hematoma (Figs. 5A, 5B).[16,22,23,28,37]

Figure 5A. Immediate postoperative radiograph demonstrating a V-osteotomy of the second metatarsal.

Figure 5B. Radiograph at eight weeks post-operative. Note the delayed union of the second metatarsal osteotomy.

## CONCLUSION

Lesser metatarsal lesions are a very difficult problem to surgically address. There are numerous osteotomies available, each with its own complications. The difficulty lies in determining the exact etiology and then determining the precise amount of correction. Further studies are needed to develop a protocol for surgical correction which could help us understand and prevent the high incidence of complications.

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