METATARSAL SURGERY - CURRENT PROCEDURES

A. Louis Jimenez, DPM

The following paper will discuss current metatarsal surgical procedures most commonly performed at Northlake Regional Medical Center. A retrospective metatarsal surgery study done at Doctors Hospital/Northlake Regional Medical Center, and an independent study done by the author will be presented.

Indications for lesser metatarsal surgery include chronic pain which has been resistant to conservative therapy and has led to disability. Reasons for morbidity relative to surgical procedures include poor patient selection, improper osteotomy site, inappropriate fixation, and inadequate postoperative follow-up care all of which can contribute to a less than desirable results. We will discuss the incision, circulation of bone, the most appropriate placement of osteotomies, the most appropriate instrumentation, fixation techniques and postoperative management.

INSTRUMENTATION

The best power instrumentation for lesser metatarsal surgery should employ thin saw blades whose cutting width does not exceed 2 mm in diameter (Fig. 1). Metatarsal surgery is confined to millimeters of correction requiring a delicate, controlled cut to avoid excessive bone resection and "overcorrection". Elevation osteotomies of the internal metatarsals require only minimal wedge resection or shortening as excessive elevation or shortening is likely to lead to postoperative complications such as transfer lesions or the classic "floating toe".

Basic concepts and principles for successful metatarsal surgery that should be discussed prior to performing metatarsal osteotomies include:

1. Circulation to the bone
2. Anatomical considerations of osteotomy performance
3. Lever arm effect
4. Vassal principle
5. Postoperative bandaging and/or casting

METATARSAL BLOOD SUPPLY

Metaphyseal bone demonstrates a tri-segmental blood flow pattern receiving in-put from epiphyseal, metaphyseal, and diaphyseal vessels (Fig. 2A). Diaphyseal bone has fewer circulatory feeders. The metaphyseal-diaphyseal junction of bone is more cellular as compared to diaphyseal bone, which is more compact and less cellular. Therefore, osteotomies performed within the more cellular cancellous anatomic and/or surgical neck of the metatarsal bone will heal faster than osteotomies performed in diaphyseal regions of the bone (Fig. 2B).

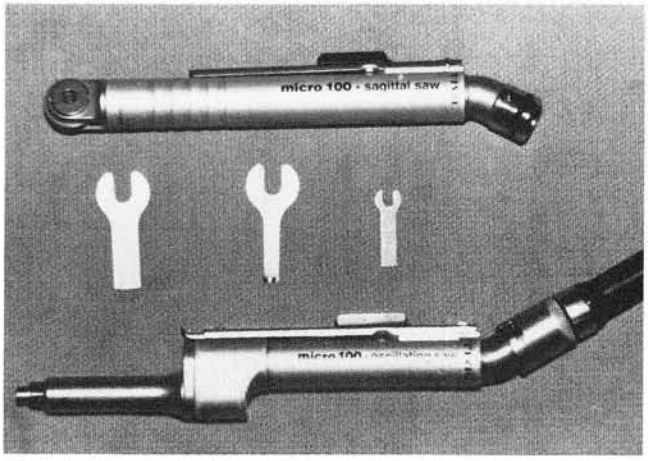

Fig. 1. Commercial power equipment demonstrating sagittal (top) and oscillating (bottom) saws. The blades are 2 mm. in thickness and available in various widths and lengths.

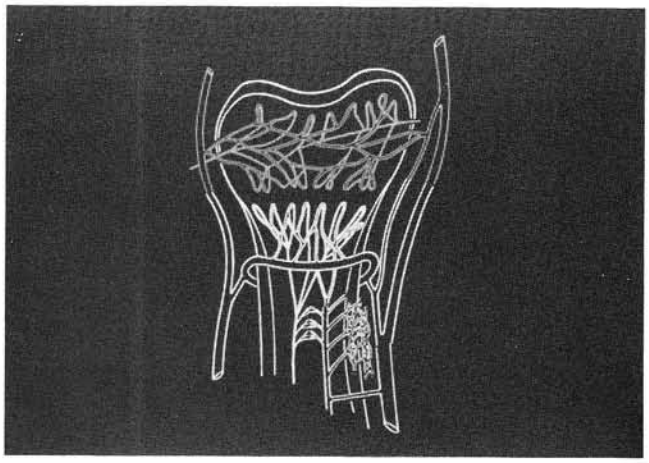

Fig. 2A. Metaphyseal-epiphyseal bone is richly supplied with epiphyseal, metaphyseal and diaphyseal blood flow.

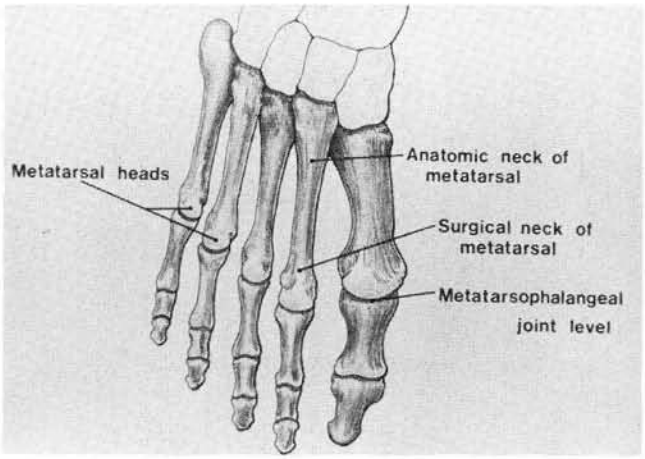

Fig. 2B. The surgical neck is a cancellous, cellular area which encourages good bone healing.

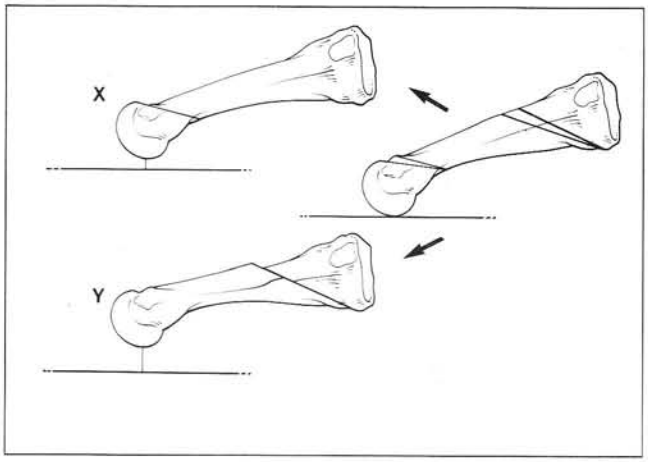

Fig. 3. X: Distal and proximal osteotomies of lesser metatarsals. Y: Removal of identical amounts of bone from the proximal osteotomy site will result in greater elevation of the distal fragment because of the "lever arm effect."

MECHANICS OF THE OSTEOTOMY

The concept of a lever arm and fulcrum become very important in determining whether to perform a metatarsal osteotomy distally or proximally. When the osteotomy is performed at the base of the metatarsal, advantage is taken of the longer lever arm. The same amount of bone removed from a proximal and distal osteotomy will create significantly different amounts of elevation of the head of the metatarsal. The longer lever arm of the proximal osteotomy technique will create a greater elevation of the distal fragment. (Fig. 3) The disadvantage of the proximal osteotomy is that a longer lever arm has a smaller margin of error and a greater chance of creating metatarsus elevatus and its associated complications.

THE VASSAL PRINCIPLE

The Vassal principle is a concept which has been described and used by Europeans in complex fracture reduction.[1] When multiple fractures are present, the fractures can be mechanically independent (autonomous fractures) or mechanically interdependent. In the mechanically interdependent fracture, one of the fractures will be predominant, called the "dominant fracture" and the other less important fracture(s) is called the "Vassal fracture." The Vassal fracture depends on the dominant fracture for its position and stability. An example of a Vassal fracture is a contiguous spiral fracture of the tibia and fibula. The fibula is held to the tibia via the tibio-fibular ligaments and the interosseous membrane (Fig. 4A). Should rotatory forces be significant, the distal fragments may shorten proximally and shift laterally. Soft tissue tension is diminished, reducing the pull on the contiguous distal segments. The same soft tissue inter-position can be used to help relocate the fragments. Once the tibial fracture has been relocated, tension is placed through the interosseous membrane and distal tibio-fibular ligaments on the fibular fragment, creating a better positional attitude to the fibular fracture (vassal fracture) (Fig. 4B).

In many circumstances, reduction of the tibial fragment is good enough that internal fixation of the fibular fracture is not necessary (Fig. 4C-4F). The same concept applies to forefoot fractures and/or metatarsal osteotomies about the forefoot. The main soft tissue inter-position between the metatarsals are the inter-metatarsal ligaments

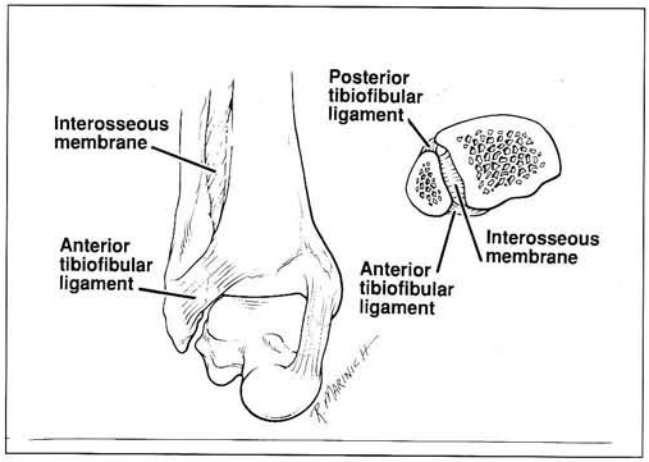

Fig. 4A. Length and position of the fibula to the tibia is maintained by the interosseous membrane and the anterior and inferior tibial-fibular ligaments.

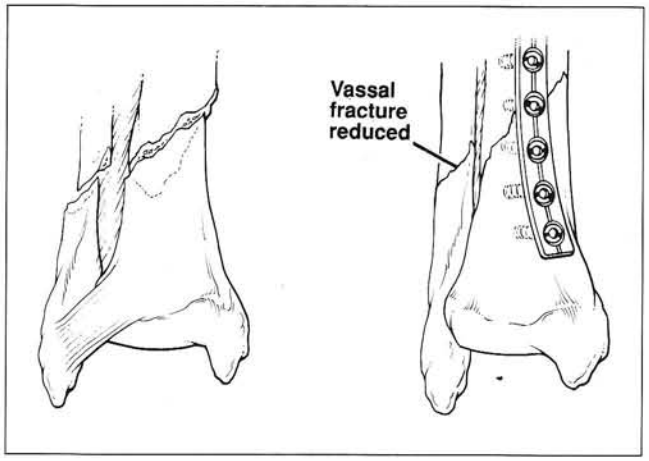

Fig. 4B. Spiral oblique fractures of the tibia (dominant) and fibular (vassal fracture) pre and post reduction.

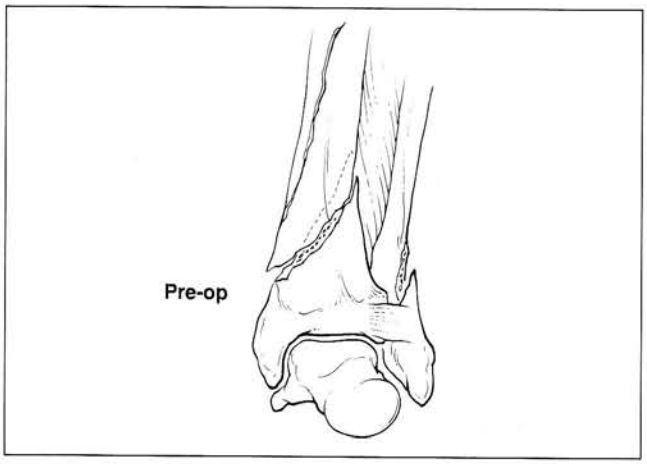

Fig. 4C. Pre-operative view demonstrates proximal-posterior displacement of the fibular fracture and lateral displacement of the tibial fragment.

Fig. 4D.

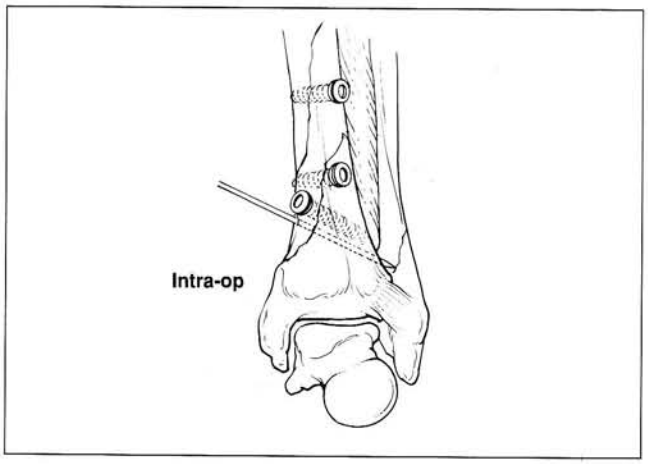

Fig. 4E. Intra-operative scout post reduction x-ray reveals the fibular fragment has assumed excellent alignment through the "Vassal Principle." Because length and rigidity of the tibia has been attained, casting is all that may be necessary to hold the fibular fracture in alignment. Note: the Kirschner wire appears to be stabilizing the fibular fracture although intra-operatively it was posterior to the fibula.

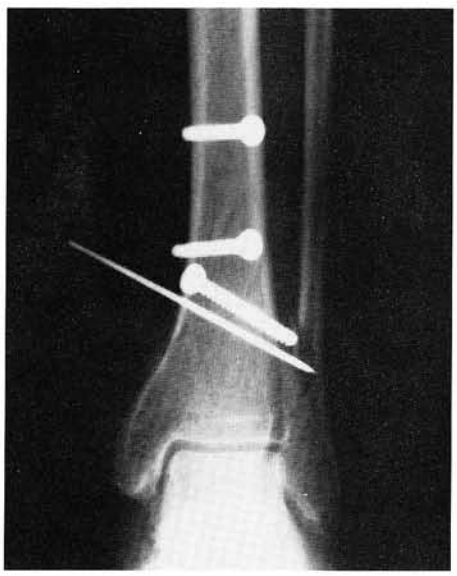

Fig. 4F.

(Fig. 5). Therefore, if a fracture of the 5th metatarsal and a fracture of the 4th metatarsal were present, reduction of the 5th metatarsal fracture could create tension on the 4th metatarsal fracture through the intermetatarsal ligament helping it to assume a better position (Fig. 6A, 6B). Not only can this soft tissue inter-position create a better positional attitude, but it can also work to the detriment of contiguous fragments especially in dealing with multiple metatarsal osteotomies.

Should one perform a first metatarsal, second metatarsal and third metatarsal osteotomy and let the patient bear weight, the Vassal principle comes into effect. The first metatarsal dorsiflexes during the midstance and early toe-off phases of gait and the transverse intermetatarsal ligament creates tension on the second metatarsal. (Fig. 7A) These forces may be sufficient to actually displace the second metatarsal head at the osteotomy. The same process occurs with the third metatarsal (Fig. 7B, 7C). For this reason, contiguous osteotomies should not be floating (non-fixated osteotomies), but should be fixated. Restriction of weightbearing should be considered until sufficient bone union has occurred.

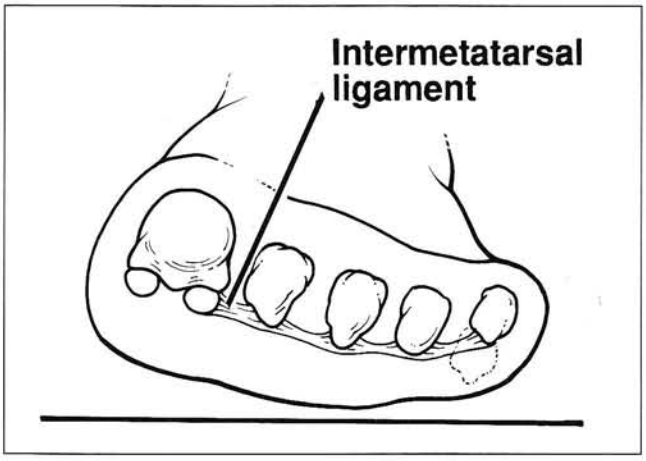

Fig. 5. Intermetatarsal ligaments attached to contiguous metatarsal bones helping to maintain proper length and alignment.

Fig. 6A. Metatarsal fracture 3-4-5 shows medial and proximal shift following an injury where the foot was run over by a school bus.

Fig. 6B. Following realignment of the fifth metatarsal fracture, the 3rd and 4th metatarsals (Vassal fractures) assume a better position due to the pull of soft tissues and intermetatarsal ligaments.

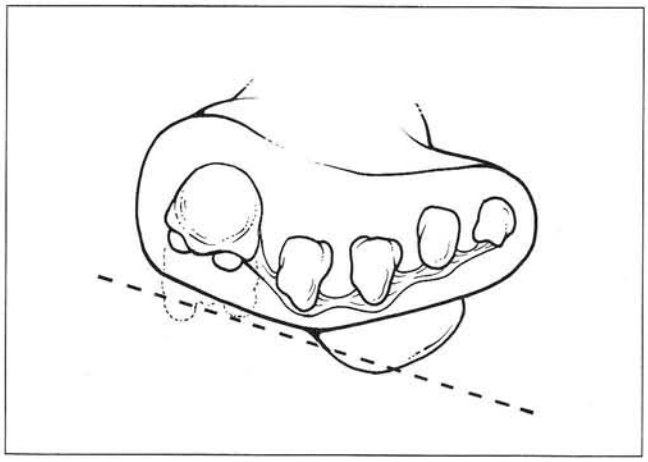

Fig. 7A. During the midstance phase of gait, as the first metatarsal dorsiflexes and inverts, tension in placed on the first intermetatarsal ligament as well as the 2nd and 3rd intermetarsal ligaments.

POSTOPERATIVE MANAGEMENT

Postoperative bandaging becomes important as well. The dressing should be applied to control edema and apply mild pressure of the distal fragment upon the proximal fragment. Thick bandaging under a distal fragment causes extra dorsal compression forces. This force can displace a floating osteotomy or fracture a weakened hinge of a fixated osteotomy and lead to delayed healing and/or transfer lesions (Fig. 8A, 8B).

SURGICAL PROCEDURE

When minimal elevation (2-5 mm) of the metatarsal head is required, the preferred procedure for structurally declinated metatarsals is an oblique dorsiflexory osteotomy performed at the surgical neck. (Fig. 9A, 9B). When more than 5 mm of elevation is needed osteotomy at the proximal metaphysis is indicated. The osteotomy is fixated with a 2.0-mm cortical screw (Fig. 10). A 2.7-mm cortical screw may be used at the proximal metaphysis since this portion of the metatarsal is generally wider. The incidence of nonunion, transfer lesions, avascular necrosis, and floating digits have dramatically declined since the implementation of rigid internal fixation. We believe the reduction of significant complications associated with rigid internal fixation occurs primarily because, the osteotomy is stable, and promotes bone healing. It also gives the surgeon better control in placing the head of the lesser metatarsal in the exact position desired.

Fig. 7B. Upon weightbearing, the second and third metatarsals dislocated. The second metatarsal was relocated by closed reduction, but relocation of the third metatarsal required open reduction.

Fig. 7C.

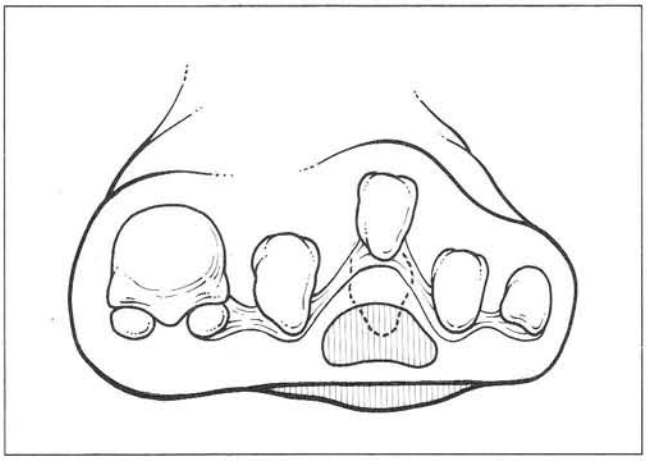

Fig. 8A. Too thick a dressing inferior to the metatarsal capital fragment has caused the third metatarsal osteotomy to heal in an abnormally elevated position.

Fig. 8B. Note transfer lesion sub fourth metatarsal as a result of the improper bandaging.

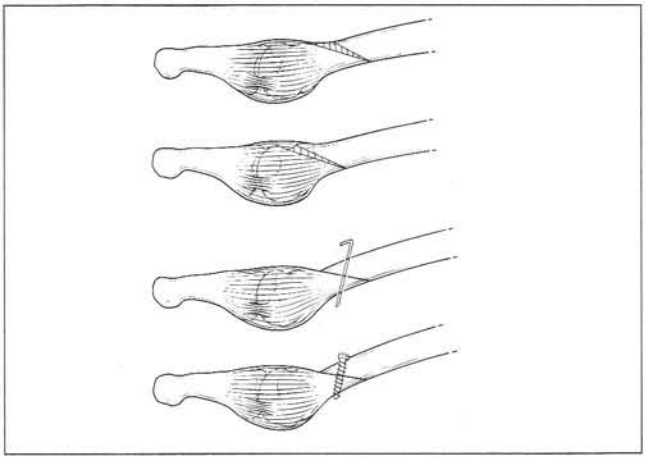

Fig. 9A. Oblique dorsiflexory "V" osteotomy as outlined in text.

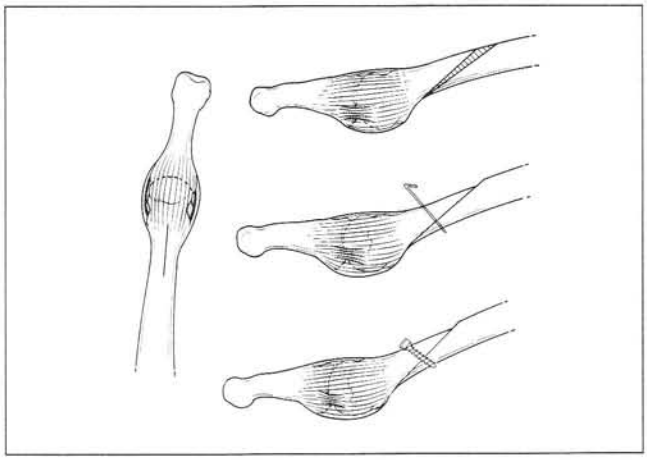

Fig. 9B. The angle of osteotomy may be directed from proximal-dorsal to distal-inferior.

Fig. 10. Oblique second metatarsal osteotomy following fixation with a 2.0 mm cortical bone screw 5 weeks post-operatively.

TECHNIQUES FOR LESSER METATARSAL SURGERY

DISTAL WEDGE OSTEOTOMY

A 4-cm linear incision is made over the metatarsophalangeal joint. The skin incision begins over the dorsal aspect of the distal half of the involved metatarsal and extends to the distal aspect of the head of the metatarsal. The incision is deepened through the subcutaneous tissues. Care is taken to avoid neurovascular structures and bleeders are tied or coagulated as needed. Subcutaneous tissues are reflected away from deep fascia identifying the dorsal, medial, and lateral capsule at the metatarsophalangeal joint. A linear deep fascial incision is made, and the extensor tendons are retracted medially or laterally. A linear periosteal

incision is then performed, and the periosteum is reflected with the use of a Freer elevator from the dorsal, medial, and lateral aspects of the neck of the lesser metatarsal. Care is taken not to injure the joint capsule and the attachments of the collateral ligaments are preserved to maintain lateral and medial stability.

An incomplete osteotomy is then performed at the neck of the metatarsal. A thin, sharp saw blade is recommended. The osteotomy begins at the surgical neck and courses proximal at an angle of about 60 degrees to the long axis of the metatarsal. Care is taken to avoid cutting through the plantar cortex. The osteotomy is held closed and the metatarsal head is palpated plantarly for comparison to the adjacent metatarsals. If a hyperkeratotic lesion exists preoperatively under the metatarsal head, it must be debrided to facilitate this evaluation. If an additional amount of dorsiflexion is desired, the osteotomy is lightly held closed and the oscillating blade is passed in and out of the osteotomy. One or two mm of bone is removed with each sweep of the blade. The osteotomy is held closed once again and palpated plantarly until the metatarsal head is raised to the appropriate level.

The preferred fixation employs a 2.0-mm cortical screw driven across the osteotomy site from dorsal proximal to plantar distal into the plantar condyles of the metatarsal head (Fig. 10). After temporary fixation is applied with the use of a small K-wire, screw fixation is performed using standard AO technique. The temporary fixation wire is removed, and the stability of the fixated osteotomy is evaluated. If unstable, a smooth 0.035-inch or 0.045-inch K-wire is directed across the osteotomy site, bent against the near cortex (entrance site), cut short, and left internally for additional stability.

The wound is copiously irrigated with normal saline and closed in anatomic layers. The foot is then dressed in a sterile dressing and placed into a synthetic cast with a rubber walking heel. The heel is preferred to a walking cast, boot, or shoe. The patient is encouraged not to "toe-off" with the cast and told to maintain most weight on the middle of the cast to avoid placing distal pressure on the forefoot, hopefully to avoid fracture of the osteotomy (Fig. 11). The patient remains in the weightbearing cast for 4 weeks and is then placed into a padded surgical shoe for 2 to 3 weeks or until osseous union can be radiologically determined.

An alternate form of fixation includes the use of a smooth 0.045-inch K wire alone, directed perpendicular to the osteotomy. The wire is bent and "buried" as previously described.

The V Osteotomy - Plantarflexory or Dorsiflexory

The skin incision as well as the periosteal incisions are performed as outlined for the oblique V osteotomy. As described by Jacoby in 1973,[2] the osteotomy is a subcapital osteotomy performed with the apex at the surgical neck. Two arms are directed proximally, one posterior lateral and the other posterior medial. It is important to keep the arms 60 degrees to the long axis of the metatarsal, as this relationship can provide inherent stability to the osteotomy. The osteotomy is completed through the plantar cortex. The osteotomy is distracted and the capital fragment is displaced dorsally approximately 2-3 mm to the appropriate level. (Fig. 12A, 12B)

Fixation is accomplished with the use of a 0.045 Kirschner wire directed through the osteotomy from superior-lateral-proximal to inferior-distal-medial. Care is taken not to enter the joint. The K-wire should be maintained sub-chondral. (Fig. 13)

Should the surgeon want to create plantarflexory displacement, the capital fragment is simply distracted and shifted inferiorly (Fig. 14). Fixation is performed as previously described.

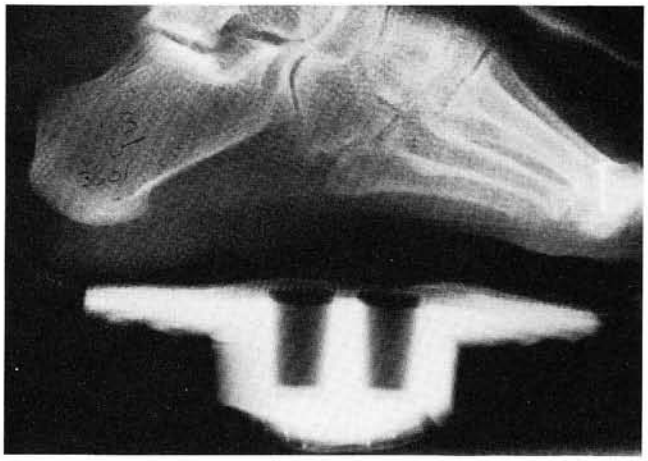

Fig. 11. Walking cast following a metatarsal osteotomy. Note walker placed slightly anterior to the long axis of the tibia.

Fig. 12A. Standard "V" osteotomy. Note osteotomy is at surgical neck and arms are 60 degrees to long axis of the metatarsal.

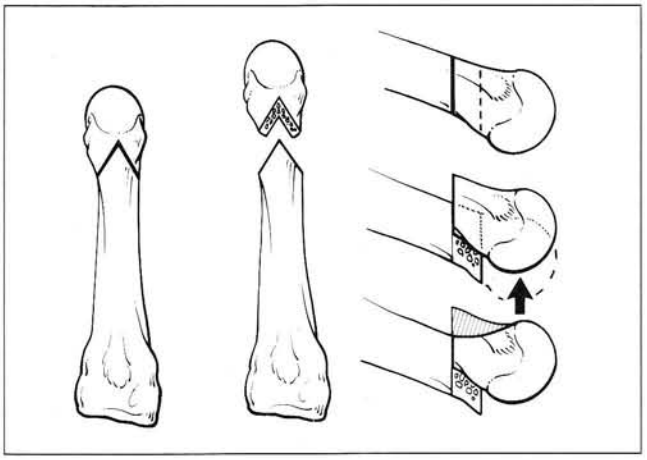

Fig. 12B. Capital fragment is superiorly displaced to corrected position.

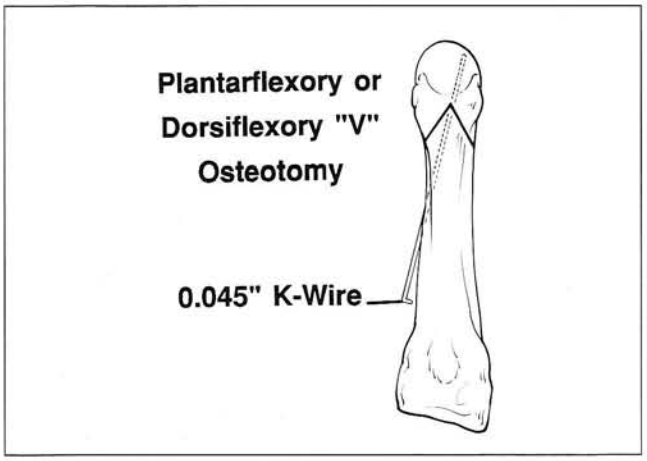

Fig. 13. V-osteotomy is fixated with 0.045" Kirschner wire maintained subchondrally.

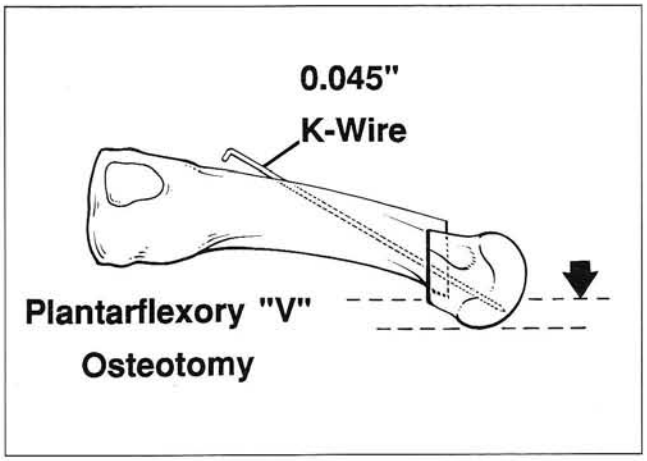

Fig. 14. Capital fragment inferiorly displaced and fixated with 0.045" Kirschner wire.

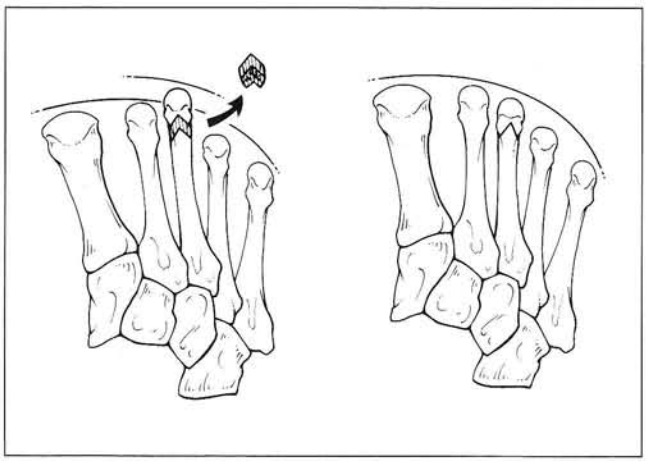

Fig. 15A. Collectomy procedure utilizing a modification of the standard "V" osteotomy to shorten bone.

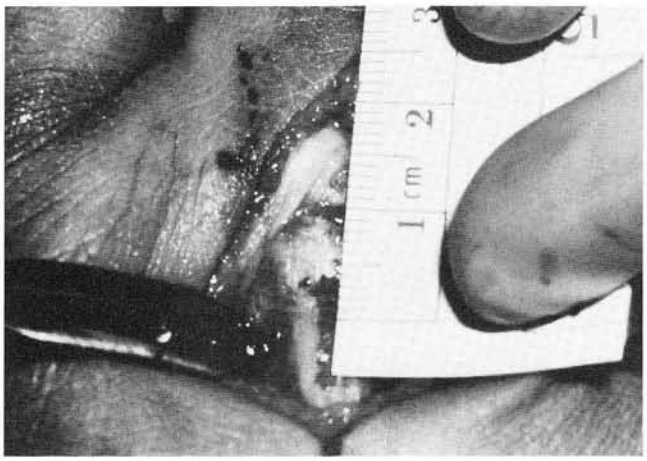

Fig. 15B. Preoperatively the exact amount of bone to be removed is determined roentgenographically. Intraoperatively the surgeon marks the amount of bone needed to be removed.

Fig. 15C. Preoperative x-ray identifying long second metatarsal.

Fig. 15D. Six weeks following digital stabilizations and colectomy of the second metatarsal. The Kirschner wire stabilizes the second digit, metatarsophalangeal joint and collectomy site.

Occasionally, an arthrodesis or other digital or metatarsophalangeal joint procedure is performed where fixation of the digit is necessitated. The osteotomy can be fixated with the same K-wire. The K-wire is passed from distal across the MPJ and through the osteotomy site. The K-wire then trans-fixates the osteotomy site, holding the toe, metatarsophalangeal joint and the metatarsal osteotomy in place (Fig. 15A-15E). All tissues are closed in routine fashion.

V-Osteotomy Incorporating a Collectomy

The V-Osteotomy incorporating a collectomy is generally indicated where shortening of the involved metatarsal is desired. The osteotomy is performed without cutting through the plantar cortex. A second V-osteotomy is placed proximal to the initial osteotomy, again without cutting through the plantar cortex. The amount of bone

Fig. 15E. Four months post-operative. All end to end proximal interphalangeal joint arthrodeses have fused and second metatarsal colectomy site is 85% consolidated.

between the osteotomy arms, is predetermined by measurements on the preoperative x-ray. The distal osteotomy is then completed through the plantar cortex followed by completion of the proximal osteotomy through its inferior cortex removing a segment of bone V-shaped corresponding to the amount needed to shorten the metatarsal. Fixation is similar to that described above.

A potential complication of the V-Osteotomy performed with a collectomy includes the "floating toe" syndrome. This complication is due to unloading of the flexor apparatus as bone content is removed from the metatarsal. If there is any potential for creation of a hammered digit, it should be addressed at this point with either an arthrodesis, or an arthroplasty with appropriate K-wire fixation.

Plantar Condylectomy

The plantar condylectomy as described by DuVries in 1953,[3] involved the removal of the inferior 1/4 - 1/3 of the plantar aspect of the metatarsal head including the plantar condyles. (Fig. 16) The procedure is not common at our institution. A "floating toe" has been described as a common complication following plantar

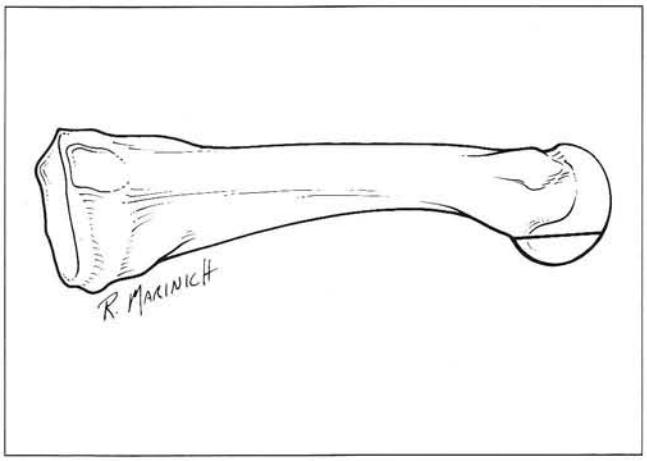

Fig. 16A. Plantar condylectomy removes the metatarsal plantar condyles.

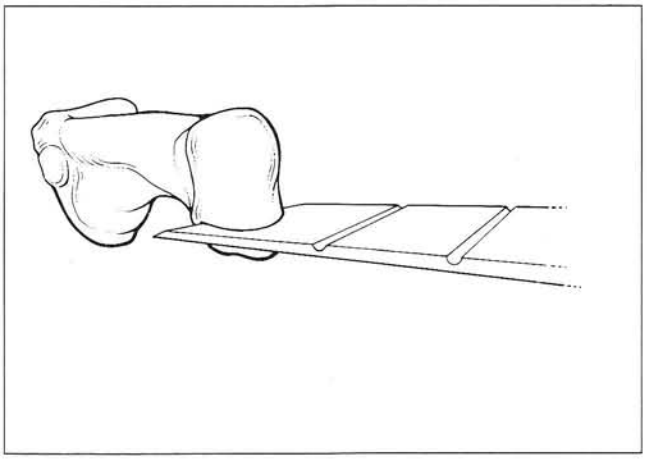

Fig. 16B.

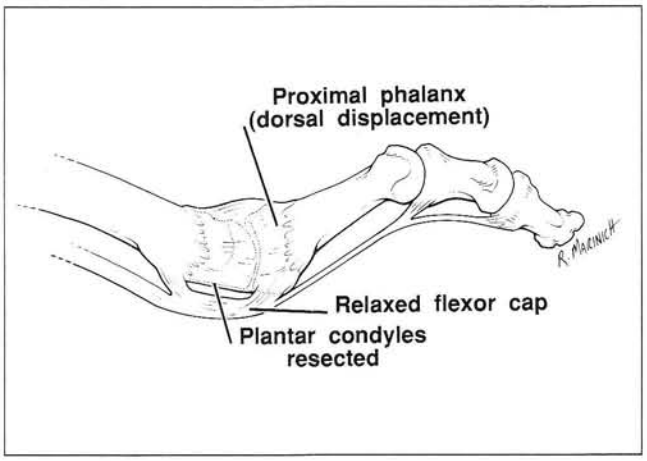

Fig. 16C.

condylectomy. It has, however, proven to be a valuable procedure in older more sedentary patients, and has been useful where previous metatarsal elevating procedures have failed.

The procedure involves a dorsal incision measuring 4 centimeters, starting at the distal 1/3

of the metatarsal and extending to the proximal 1/3 of the proximal phalanx of the involved digit. It is deepened through sub-cutaneous tissues in a routine fashion to the periosteum which is incised linearly. Periosteum and capsular structures are reflected medially and laterally. The medial and lateral collateral ligaments are sacrificed and a sesamoid clamp or towel clamp is placed around the neck of the metatarsal to pull the metatarsal superiorly. Occasionally, if significant adhesion is present inferiorly, a scoop-type elevator (McGlamry or mastoid elevator) is useful in releasing the metatarsal head. The plantar condyles are visualized along with the metatarsal head and an osteotome is used to remove the inferior 1/4 of the metatarsal heads. Care is taken to remodel the bone inferiorly, and remove sharp edges. After copious lavage, the capsule is closed and further closure is accomplished in routine fashion.

Excision of Plantar Keratosis

The plantar hyperkeratotic lesion is not excised as a general part of routine metatarsal surgery. However, the author has found in a small number of cases, a recalcitrant, extremely painful, deep nucleated lesion remains even after an adequate dorsiflexory osteotomy has been performed. Excision of the lesion has proven to be of value in these patients.

The procedure involves two semi-elliptical incisions in a 3:1 ratio, removing the lesion so that normal skin edges may be approximated. Closure of the lesion is usually performed with 4-0 non-absorbable sutures in simple interrupted fashion. The patient is non-weightbearing for approximately two weeks. The sutures are then removed and weightbearing is allowed. To date, the author has observed no untoward effects from this procedure when appropriate postoperative care is followed. One must be aware that hypertrophic scarring may result when premature weightbearing on the surgical site is allowed.

RETROSPECTIVE LESSER METATARSAL STUDY DOCTORS HOSPITAL/NORTHLAKE REGIONAL MEDICAL CENTER/ PODIATRY INSTITUTE

The Doctors Hospital/Northlake Regional Medical Center/Podiatry Institute study of lesser metatarsal surgery consisted of a retrospective survey from 1970 to 1989. During this time 1,202 osteotomies (average 60.10 per year) were performed. It is interesting to note that between the years 1970 - 1980 as podiatric surgery became more common, a greater number of metatarsal procedures were performed. After 1980, the number of metatarsal osteotomies diminished significantly (Fig. 17). There are a number of reasons why these numbers diminished. With a greater

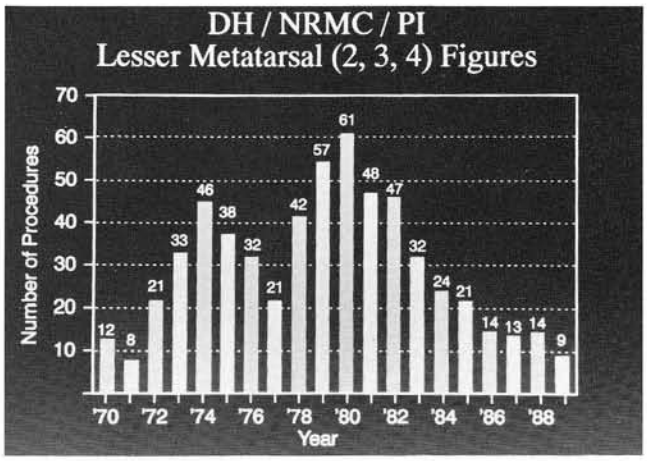

Fig. 17. Note increase in lesser metatarsal osteotomies from 1970-1980 and significant decrease thereafter.

appreciation for the biomechanical effects of weightbearing on the first metatarsal, it became evident that if one were to perform an osteotomy on the first metatarsal, making it weightbearing again, less pressure would be placed on the second metatarsal. In hallux abducto valgus surgery, plantar flexion of the first metatarsal became an important component of correction of the primary deformity.

The pathomechanics of hammer toe deformity resulting in sub-metatarsal lesions has been more commonly appreciated in the last 15 years. With digital stabilization retrograde forces through the metatarsal are diminished, decreasing

the amount of pressure on the plantar fat pad, and reducing plantar hyperkeratoses.

Between 1980 and 1989 more effective fixation techniques were used, decreasing the morbidity of bone healing, and potential recurrence of lesions and/or transfer lesions.

Along with this study, a questionnaire was sent to 15 Podiatry Institute faculty members who performed surgery at Doctors Hospital/Northlake Regional Medical Center (Fig. 18A, 18B). The average length of time in practice for the entire group was 10.3 years. The results were as follows: the most common type of osteotomy was the long oblique osteotomy (53%), followed by the standard V-type osteotomy (33%), followed by the plantar condylectomy (7%), and other (7%). Osteotomy was performed at the distal surgical neck 80% of the time, and proximally 7% of the time.

Fixation was carried out in 93% of all cases. K-wire fixation (.045" or .062") was used in 40% of the cases. Screw fixation was performed 53% of the time with either a 2.0 mm or 2.7 mm cortical bone screw. Postoperative control was with either a shoe (53%) of which 86% were nonweightbearing for 4 weeks, or cast control with a very close split between weightbearing and nonweightbearing. Osteotomies were performed most commonly on the 3rd metatarsal, followed by the 4th, then the second.

The average age of the patient was 40.71 years, and the percentage of resolution of the lesion was 71.35%. The most common complication was transfer lesions in 33% of the patients, followed by delayed union, "dorsal bump" at the osteotomy site, recurrence, and digital problems (retraction and/or floating toes). After osseous healing, postoperative control was with orthoses (80%). When the faculty was asked if they would have a lesser metatarsal osteotomy performed for a painful lesion, 67% answered yes, 20% answered no, and 13% were undecided. From these percentages one would speculate that should the lesion become painful, an osteotomy would be accepted by the surgeon.

The author performed a retrospective study on the patients in his practice from 1980 to 1990 (Fig. 19). All surgery was performed either personally by the author, or under his direct supervision. One hundred and eight metatarsal osteotomies were performed during this time

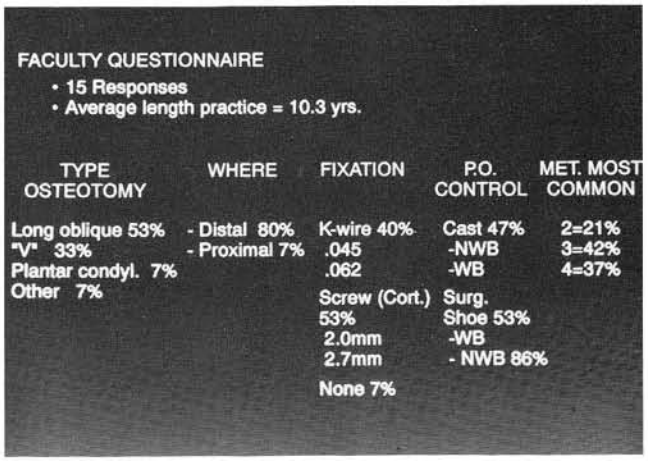

Fig. 18A. Questionnaire results posed to Doctors Hospital/Northlake Regional Medical Center podiatric faculty.

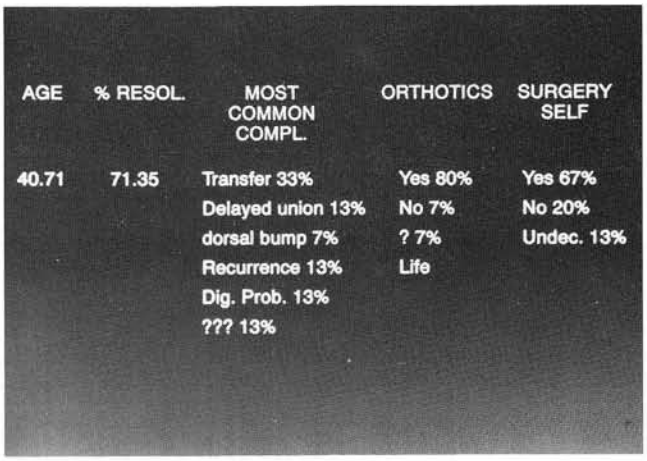

Fig. 18B. Questionnaire results.

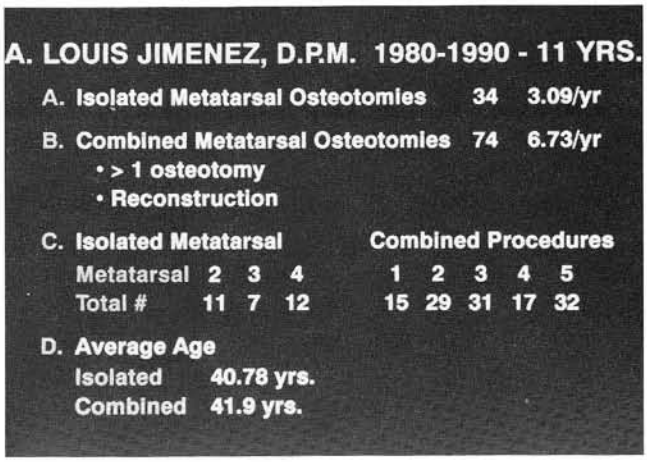

Fig. 19. Retrospective study of lesser metatarsal osteotomies by A. Louis Jimenez, D.P.M.

span. They were further divided into isolated osteotomies, combined metatarsal osteotomies where more than one metatarsal osteotomy was performed, and reconstructive foot surgery, where more than one type of podiatric procedure was performed.

There were 34 (3.09 per year) individual isolated metatarsal osteotomies versus 74 (6.73 per year) combined metatarsal osteotomies. The osteotomy was performed most frequently on the fourth metatarsal, followed by the second, and then the third. With combined procedures, the osteotomy was performed most commonly on the second metatarsal (when only the second third and fourth metatarsals were evaluated). Isolated metatarsal osteotomies were performed in patients whose average age was 40.78 years, and combined metatarsal procedures were performed in patients whose average age was 41.9 years. All metatarsals were stabilized with either K-wire or screw fixation, unless the patient was going to be completely non-weightbearing for six weeks, in which case, standard "V" osteotomies may not have been fixated.

SUMMARY

Metatarsal surgical procedures are a rare occurrence at Northlake Regional Medical Center. Indications for surgery include chronic pain creating disability and resistance to conservative therapy. Reasons for morbidity include improper selection of osteotomy site, improper usage of power or hand instrumentation, weak or non-existent fixation technique, and early weightbearing on an already unstable osteotomy.

The concepts of the lever arm effect, the Vassal principle, anatomic considerations, and circulatory components of bone have been discussed. These factors when well understood and properly used enhance bone healing and reduce postoperative morbidity.

The most common surgical procedures for lesser metatarsal osteotomies, performed at Northlake Regional Medical Center in order of frequency are the oblique dorsiflexory metatarsal osteotomy, standard V-osteotomy, standard V-osteotomy with collectomy, plantar condylectomy, and occasionally wide excision of the lesion. Ninety three percent of procedures are rigidly fixated.

A retrospective 20 year follow-up study from Doctors Hospital/Northlake Regional Medical Center has shown that the number of lesser metatarsal osteotomies has decreased significantly. Fixation and immobilization techniques are much more common. Non-weightbearing or minimal weightbearing for four weeks is standard postoperatively.

The strict criteria that have been discussed, along with the early findings of the retrospective study, should lead the podiatric physician to view metatarsal surgery as a very useful entity in a very select group of patients.

REFERENCES

1. Heim U, Pfeiffer KM: *Small Fragment Set Manual,* New York, Springer-Verlag, p. 26, 1974.
2. Jacoby RP: V-Osteoplasty for correction of intractable plantar keratosis. *J Foot Surg,* 12:8-10, 1973.
3. Duvries HL: New approaches to the treatment of intractable verruca plantaris (plantar wart). *JAMA* 152:1202-1203, 1953.

ADDITIONAL REFERENCES

Jimenez AL: Oblique "v" lesser metatarsal osteotomy. In Schlefman BS (ed): *Doctors Hospital Podiatric Education and Research Institute Twelfth Surgical Seminar Syllabus,* Tucker, Ga. Doctors Hospital Podiatry Institute, p. 82, 1983.

Jimenez AL: Reconstruction of Ankle Fracture Malunion. In DiNapoli DR (ed): *Reconstructive Surgery of the Foot and Leg Update '90.* Tucker, Ga. Podiatry Institute, pp. 167-173, 1990.

Jimenez AL, Martin DE, Phillips AJ: Lesser Metatarsalgia Evaluation and Treatment. Higgins KR, Krych SM, (ed): *Clinics in Podiatric Medicine and Surgery.* Philadelphia, W.B. Saunders, pp. 597-618, 1990.

Jimenez AL, McGlamry ED, Green DR: Lesser Ray Deformities. In McGlamry ED (ed): *Comprehensive Textbook of Foot Surgery,* Vol. 1. Baltimore, Williams & Wilkins, pp. 57-113, 1987.