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Middiaphyseal Osteotomies

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Hallux abducto valgus is a progressive deformity. As the deformity increases, the retrograde force from the abducted hallux results in ever-increasing metatarsus primus varus. The subchondral bone of the first metatarsal head adapts resulting in deviation of the proximal articular set angle (PASA).

When metatarsus primus adductus is combined with hallux abducto valgus deformity, it must be corrected in addition to the repair of the first metatarsophalangeal joint. More than 130 different surgical approaches have been utilized in the correction of hallux valgus. Further, approximately 75 percent of these procedures are modifications of certain basic operations, thus suggesting at very least there is no perfect procedure available. One must remember the primary goal of surgical treatment of the patient with hallux abducto valgus deformity is to reduce pain, restore the articular congruency to the first metatarsophalangeal joint, and restore the alignment of the first ray. With this in mind, let us delve into the possibilities of correction of deformity at the level of the first metatarsal.

Middiaphyseal osteotomies to correct the metatarsus primus varus component associated with hallux abducto valgus deformity have been described by Ludloff, Mau, and Meyer. Each operation is based on its author's concept of the relative importance of the various aspects of the pathologic anatomy.

THE LUDLOFF OSTEOTOMY

The Ludloff osteotomy was first described in 1918 as a through-in-through, middiaphyseal osteotomy extending from dorsal proximal to plantar distal. The

design of the osteotomy allows the distal capital fragment to rotate or slide laterally in the transverse plane for the correction of the metatarsus primus varus component associated with hallux valgus deformity (Fig. 16-1).

Unfortunately, without the use of rigid internal fixation techniques the Ludloff osteotomy was subject to complications resulting from the loading force placed on the first metatarsal during weight-bearing. Today, with the introduction of the Swiss technique of rigid internal fixation, middiaphyseal osteotomies can be successfully executed, resulting in primary bone healing.

Preoperative Signs and Symptoms

The following are indications suggesting use of the Ludloff osteotomy:

- Hallux abducto and/or valgus deformity
- Presence of splay foot
- Presence of adductus forefoot
- Pressure of the hallux against the second digit
- Pain with shoe gear

Preoperative Radiographs

The following views should precede surgery:

- Intermetatarsal angle greater than 13° in a rectus foot and greater than 11° in an adductus foot type
- Abnormal hallux abductus angle
- Normal-to-negative metatarsal protrusion distance
- Normal PASA
- Normal bone density without osteoporosis

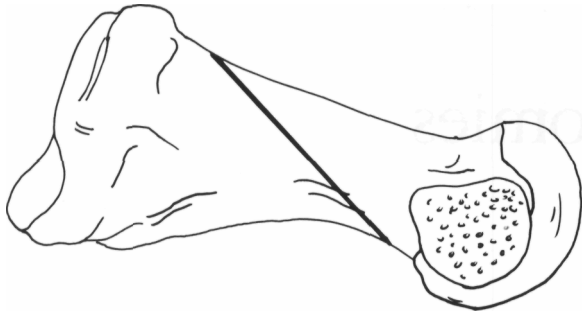


Fig. 16-1. Ludloff first metatarsal osteotomy.

Operative Technique

A 7-cm dorsolateral incision is made, immediately medial and parallel to the extensor hallucis longus tendon over the first metatarsophalangeal joint. The incision is deepened, using sharp and blunt dissection with careful attention to maintain hemostasis to the level of the joint capsule. The wound margins are retracted laterally over the first interspace. The extensor hallucis longus tendon is retracted medially, with care to avoid violation of its tendon sheath. The first interspace is entered by sharp and blunt dissection until the appropriate soft tissue structures have been released.

Attention is then directed medially to the first metatarsophalangeal joint capsule, where a linear or inverted L capsular incision is performed. Capsular and soft tissue structures are freed with great care to avoid disturbing the dorsal synovial fold of the first metatarsophalangeal joint. The medial eminence is removed with an osteotome and mallet or power instrumentation.

The initial skin incision is extended 3 cm proximally to the first metatarsocuneiform joint. A linear periosteal incision is made medial and parallel to the long extensor tendon. Periosteal tissues are reflected gaining exposure to the location of the osteotomy site. A through-in-through osteotomy is performed from medial to lateral, using a power sagittal saw. The osteotomy is angled through the middiaphyseal region of the bone from dorsal proximal to plantar distal. The distal segment can be laterally translated and swiveled. The distal segment may be lengthened by sliding it

forward on the osteotomy axis, permitting distal and plantar migration of the first metatarsal (Fig. 16-2).

A bone clamp is used to gain temporary fixation, and intraoperative radiographs are obtained to ensure proper alignment. If overcorrection is noted on the intraoperative radiograph, then it is a simple matter of releasing the bone clamp and repositioning the distal capital fragment without any further bone resection. The osteotomy is then fixated, most frequently using two 2.0 or 2.7-mm cortical screws.

The medial capsule of the first metatarsophalangeal joint is repaired using simple interrupted sutures of 2-0 Dexon. The periosteum is closed with 3-0 Dexon sutures, and the subcutaneous tissues are reapproximated and closed with suture material of the surgeon's choice.

Postoperative Management

The following steps are recommended after the Ludloff osteotomy:

Below-the-knee, non-weight-bearing cast for 6 weeks.

Initial postoperative radiographs are taken following the surgery and during the postoperative course to evaluate bone healing.

Cast may be bivalved postoperatively and sutures removed 1 week to 10 days postoperative.

Cast is removed at week 6, although final determination for discontinuing casting should be made by clinical and radiographic examination.

Patients are expected to return to normal shoe gear approximately 7 to 8 weeks if there are no complications.

Advantages and Disadvantages

The Ludloff osteotomy uses the principle of the plane of motion, to rotate or slide the distal segment on the most proximal aspect of the osteotomy. This allows the surgeon to direct the distal segment using a single cut, sliding or rotating the osteotomy along the plane created by the osteotomy and taking advantage of the long axis arm provided by the osteotomy.

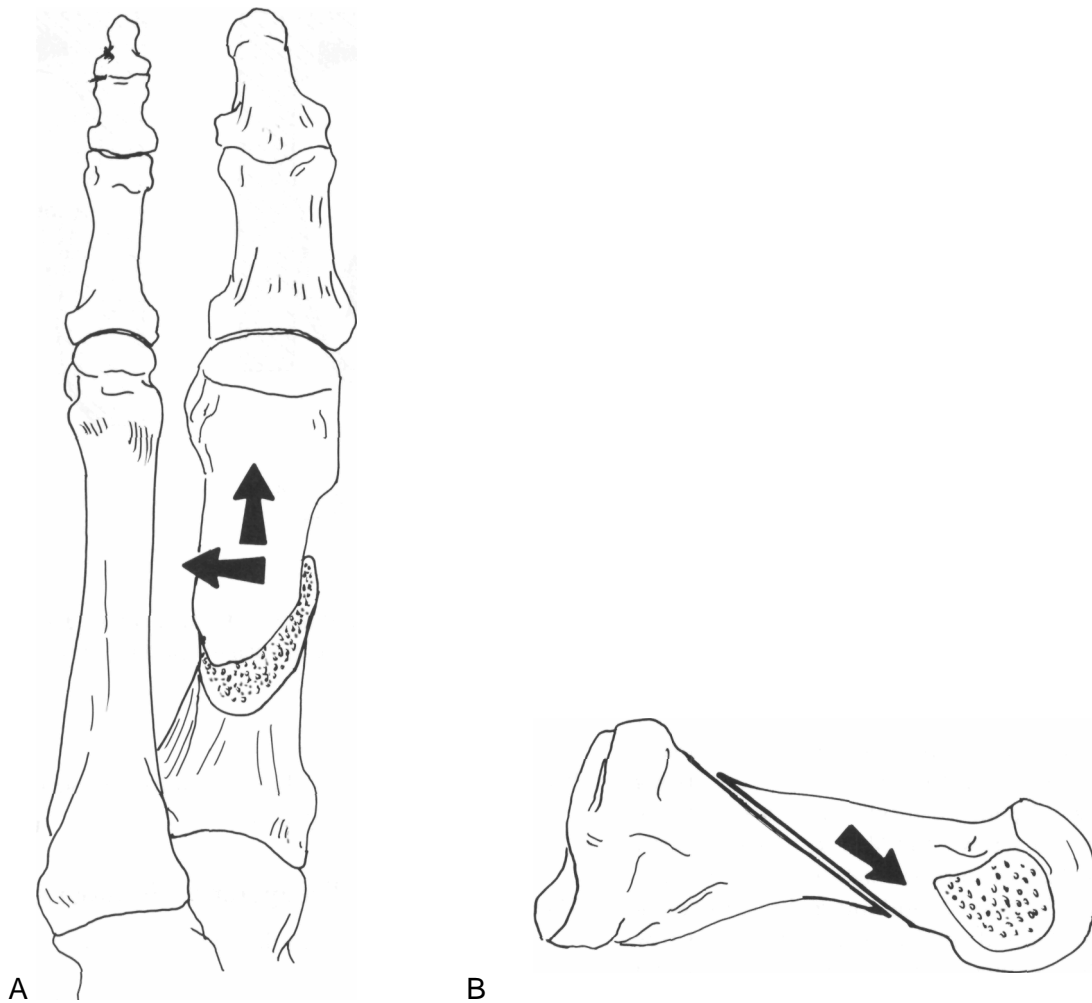


Fig. 16-2. (A) Dorsal view. Displacement of the distal segment, lateral and lengthened distally. (B) Lateral view. Distal translation; lengthen and plantar-flex the first metatarsal.

The concept of the plane of motion is utilized in other metatarsal osteotomies such as the Austin bunionectomy and the scarf or Z osteotomy. The distal segment is moved in a single plane created by the osteotomy. This single cut will allow the surgeon to move the distal segment a number of times until satisfied with the correction, without fear of further wedge resection and fracture of the medial cortical hinge as seen in wedge resection osteotomies (Fig. 16-3).

The Ludloff osteotomy lacks intrinsic stability and

requires A-O osteosynthesis with non-weight-bearing (NWB) cast immobilization. Troughing of the metatarsal can result if the distal capital fragment slides laterally beyond the cortical walls of the metatarsal, resulting in frontal plane motion.

MAU OSTEOTOMY

Mau, in 1926, modified the Ludloff osteotomy by changing the direction of the cut. Angled from dorsal

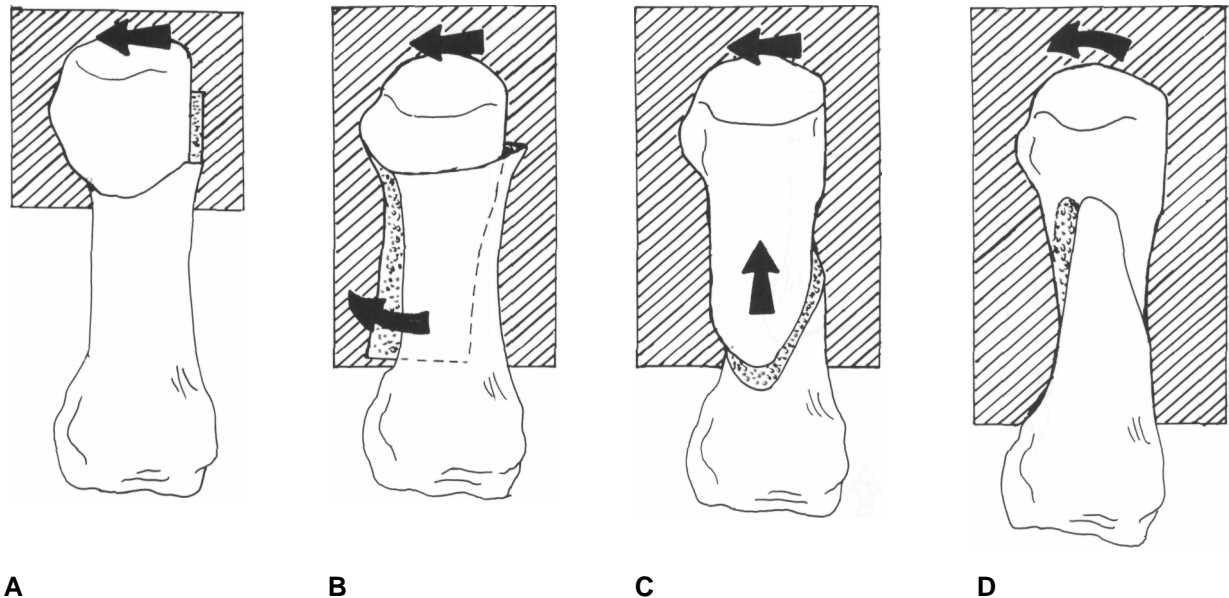


Fig. 16-3. Plane of motion for four osteotomies: (A) Austin; (B) Scarf; (C) Ludloff; (D) Mau. All use transverse cuts to laterally displace or rotate the distal capital fragment for correction of metatarsus primus varus component associated with hallux abducto valgus deformity.

distal to plantar proximal, the osteotomy attempted to prevent dorsiflexion of the distal segment during weight-bearing. Again, without the use of interfragmentary AO screws, the Mau lost its popularity because of the lack of intrinsic stability (Fig. 16-4).

With the introduction of rigid internal fixation techniques, both the Ludloff and Mau osteotomies can now be successfully executed utilizing the concept that the crescentic osteotomy tried to employ. The transverse osteotomies rely on correction by degrees in the transverse plane rather than millimeters of bone by wedge resection. Both the Ludloff and Mau osteotomies take advantage of its long radius arm to provide sufficient lateral displacement of the distal segment, correcting large adductus deformities (Figs. 16-5, 16-9).

Preoperative Signs and Symptoms

The following are indications for employing the Mau osteotomy:

- Hallux abductus and or valgus deformity
- Presence of splay foot
- Presence of adductus forefoot

- Pressure of the hallux against the second digit
- Pain with shoe gear

Preoperative Radiographs

These views should precede surgery:

- Intermetatarsal angle greater than 13° in a rectus foot and greater than 11° in an adductus foot type
- Abnormal hallux abductus angle
- Normal-to-negative metatarsal protrusion distance

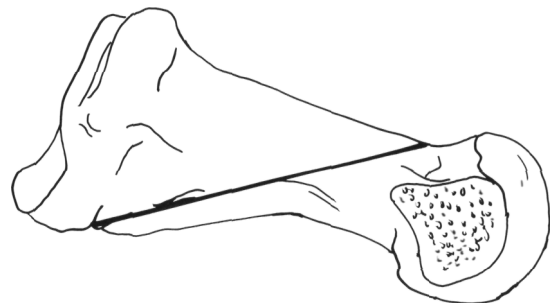


Fig. 16-4. Mau first metatarsal osteotomy.

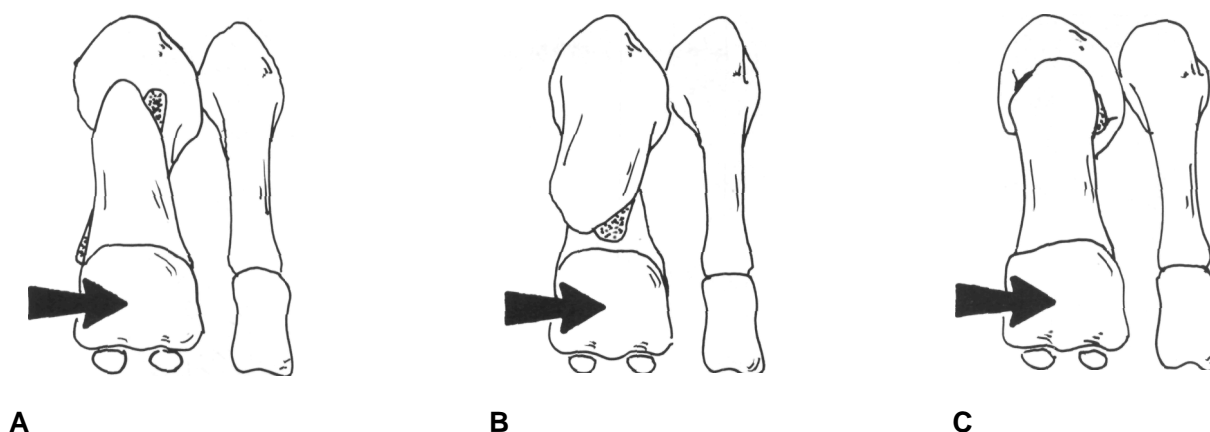


Fig. 16-5. Three osteotomies: (A) Ludloff; (B) Mau; (C) crescentic. These move the distal segment in the transverse plane without wedge resection, taking advantage of a long radius arm.

Normal PASA unless corrected by additional procedure

Normal bone density without osteoporosis.

Operative Procedure

The surgical approach used in the Mau osteotomy is the same as in the Ludloff procedure. However, the osteotomy should be made parallel to the weight-bearing surface from dorsal distal to plantar proximal through the shaft of the first metatarsal. The obliquity of the osteotomy is limited by the pitch of the proximal lateral cortex of the first metatarsal shaft. Care should be maintained to avoid entering the first metatarsocuneiform articulation. Once the osteotomy is completed, an axis guide is established at the proximal portion of the osteotomy using a small Kirschner wire. The Kirschner wire is angled perpendicular to the osteotomy, allowing the distal fragment to pivot laterally and thus reducing the intermetatarsal angle. Once the distal segment is moved, the osteotomy is temporarily fixated with a bone clamp. Intraoperative radiographs are obtained to ensure proper alignment. If overcorrection is noted on the intraoperative films, then it is a simple matter of repositioning the distal segment to the correct angle before fixation without any further bone resection. The axis wire is then removed, and the medial cortical overlap is reduced with power equipment (Fig. 16-6).

Attention is then directed to the first metatarsophalangeal joint, and the congruency is accessed. Reduc-

tion of a large intermetatarsal angle frequently increases the PASA, requiring a distal subcapital osteotomy. This is accomplished by using a Reverdin-Green osteotomy and fixating with two Orthosorb absorbable pins (Fig. 16-7).

The medial capsule of the first metatarsophalangeal joint is repaired using simple interrupted sutures of 2-0 Dexon. The periosteum is closed with 3-0 Dexon sutures, and the subcutaneous tissues are reapproximated and closed with suture of the surgeon's choice.

Modifications to the Mau Osteotomy

Increasing the length of the osteotomy can reduce a severe metatarsus varus deformity with minimal rotation of the distal capital fragment and adequate bone contact. This however is accomplished by extending the proximal cut of the osteotomy into the plantar portion of the first metatarsocuneiform articulation. At first, entering the joint posed some concerns of possible postoperative pain and degenerative arthritis. It is now apparent, after 2 years follow-up, that no postoperative pain or degenerative changes have been noted when the osteotomy enters the joint at the plantar one-fifth of the first metatarsal base (Fig. 16-8).

By utilizing this modification, the plantar ligamentous structures and insertion of the peroneus longus tendon at the base of the first metatarsal provides stability to the distal segment. This eliminates the need for an Kirschner wire guide to rotate the capital fragment. The distal segment can be easily rotated using

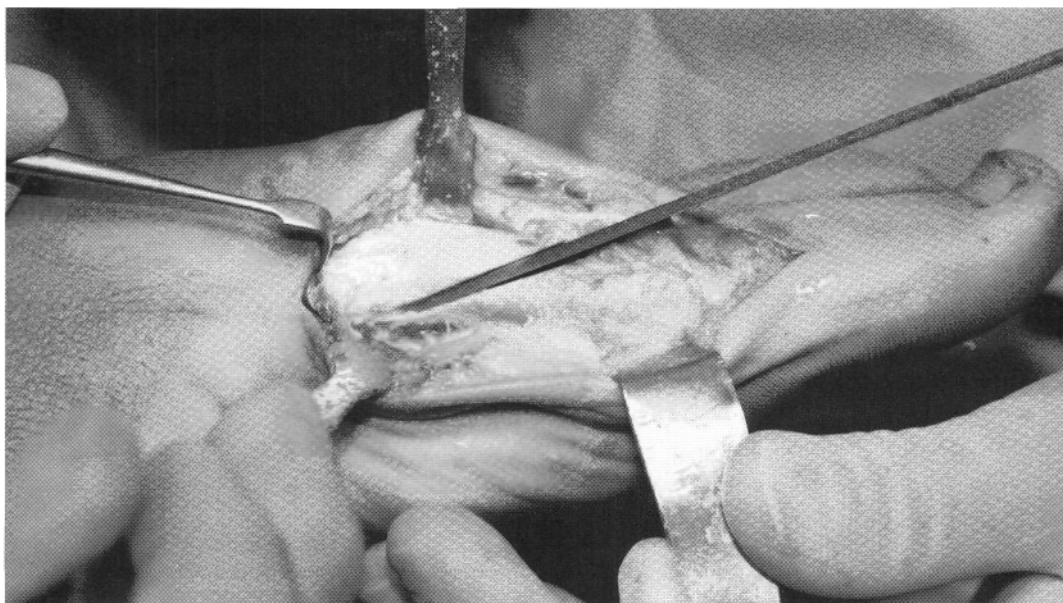


Fig. 16-6. Mau osteotomy. Cut is angled from dorsal distal to plantar proximal through the shaft of the first metatarsal. A small osteotome is used to free plantar soft tissues before displacement.

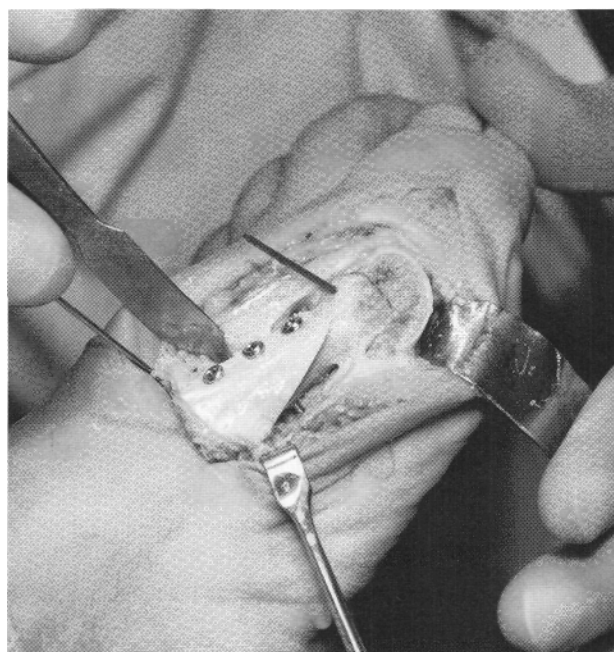


Fig. 16-7. Mau osteotomy completed and fixated using three 2.0-mm cortical screws. Distally, a Green-Reverdin subcapital osteotomy is fixated with two Orthosorb absorbable pins.

the plantar structures attached to the base of the first metatarsal as its axis guide (Fig. 16-9).

Postoperative Management

These conditions should be met after the Mau osteotomy:

Below-the-knee, non-weight-bearing cast for 6 weeks.

Initial postoperative radiographs are taken following the surgery and during the postoperative course to evaluate bone healing.

Cast may be bivalved postoperatively and sutures removed 1 week to 10 days postoperative.

Cast is removed at week 6 although final determination for discontinuing casting should be made by clinical and radiographic examination.

Patients are expected to return to normal shoe gear after approximately 7 to 8 weeks if no complications.

Advantages and Disadvantages

The Mau, like the Ludloff osteotomy, can effectively reduce the metatarsus varus component associated

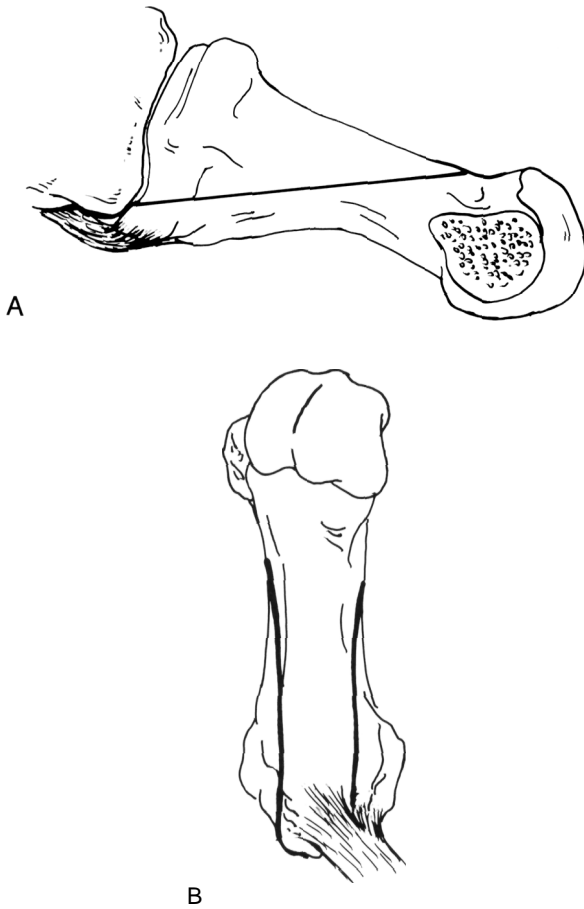


Fig. 16-8. (A & B) Modifications of the Mau osteotomy. The proximal cut is extended into the plantar portion of the base of the first metatarsal. The modification increases the length of the distal fragment, reducing a large intermetatarsal angle with minimal displacement. The plantar intrinsic provides stabilization of the plantar segment during displacement.

with hallux abducto valgus deformity. Both osteotomies are transverse plane osteotomies correcting the deformity in degrees rather than by wedge resection. However, the Mau osteotomy offers some inherent stability with the aid of internal fixation. Mau modified the angle of the Ludloff osteotomy to prevent dorsal dislocation and elevation of the capital fragment postoperatively. The authors believe that there is a plastic deformation of bone that continues for as much as 6 months in the weight-bearing bones of the feet. Therefore, if the osteotomy is remodeling during this period, the forces of the weight-bearing will affect the



Fig. 16-9. Radial arm theory. Doubling the length of the arm reduces the degrees required to move from point A to point B.

bone until this period of deformation ceases, according to Wolf and Davis Law (Fig. 16-10).

Looking at the forces applied to the first metatarsal during gait, it is clear that elevation will occur at an osteotomy like the transverse wedge if deformation occurs. Studies by Zlotoff, Schuberth, Curda, and Sorto show three main complications following proximal wedge resection osteotomies for the correction of metatarsus varus associated with hallux valgus: hallux varus, first metatarsal elevation, and first metatarsal shortening.

The Mau and Ludloff osteotomies offer an alternative approach to correction of metatarsus primus adductus when criteria are met for a closing abductory base wedge osteotomy. Both osteotomies can not only correct for significant intermetatarsal deviation of the first metatarsal, but do so more effectively by eliminating possibilities of complications inherent to the closing base wedge osteotomy (Fig. 16-11).

SCARF-MEYER Z OSTEOTOMY

A Z-type osteotomy of the first metatarsal for the correction of hallux valgus was first described by Meyer

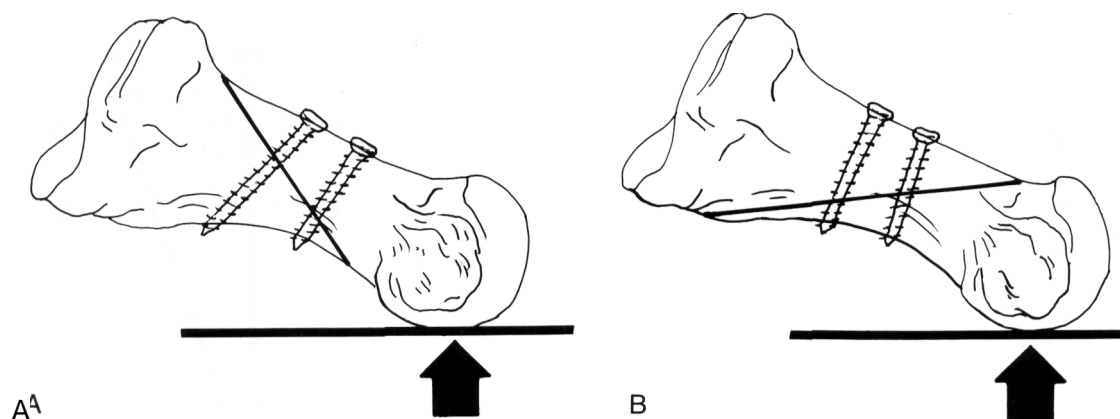


Fig. 16-10. (A & B) Ground reactive force produces a constant dorsiflexory force during ambulation. Plastic deformation will produce dorsiflexion of the distal segment during remodeling phase. Angulation of the Mau osteotomy closely parallels the weight-bearing surface, preventing elevatus.



Fig. 16-11. Mau osteotomy 12 months after surgery.

in 1926. Gudas, in 1983, popularized the osteotomy to include interfragmentary AO screws. Since this time, the Scarf or Z osteotomy has been modified in length and fixation techniques (Fig. 16-12).

The Scarf, described by Gudas, is a horizontally directed Z-displacement osteotomy of the head and shaft of the first metatarsal fixated by two cortical screws. Modification of this procedure by shortening the length of the osteotomy was described by Clickman, Pollack, and Gill. By varying the length of the osteotomy, the intermetatarsal angle as well as the PASA can be corrected by taking advantage of the inherited stability of the Scarf cuts. Schwartz and Groves modified the fixation technique by utilizing internally threaded Kirschner wires.

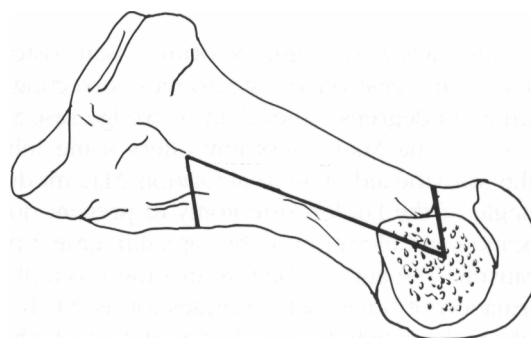


Fig. 16-12. Scarf or Z first metatarsal osteotomy.

Preoperative Signs and Symptoms

These are indications for the Scarf or Z osteotomy:

Hallux abductus with medial or dorsomedial bunion deformity
Absence of significant valgus rotation of the hallux
Pain with shoe gear and ambulation

Preoperative Radiographs

The following conditions should be visualized before osteotomy:

Abnormal hallux abductus angle
Congruous to deviated first metatarsophangeal joint
Mild to moderate increase in the metatarsus primus adductus angle
Absence of cystic changes throughout the metatarsal head
Adequate bone stock without osteoporosis
Normal to moderate increase in PASA

Operative Technique

A 5- to 6-cm skin incision is made longitudinally, centered over the shaft and head of the first metatarsal halfway between the medial eminence and the extensor hallucis longus tendon. Dissection is carried down to the level of the joint capsule and the periosteum, with care to retract the neurovascular structures. One or two linear semielliptical capsular incisions are made over the medial capsule. The periosteal incision is made by extending the capsular incision proximally, passing over the dorsomedial aspect of the shaft of the first metatarsal. The capsule and periosteum are retracted, and the medial eminence is then removed. A subcutaneous tissue plane is established over the head of the first metatarsal, and the lateral structures are identified and released if contracted.

A transverse Z osteotomy is made horizontally. The central limb is placed at the level of the middle and lower one-third of the metatarsal shaft. The dorsal wing is centered in the metaphyseal region of the head of the first metatarsal, creating an angle of 60°-70°. Proximally, the plantar wing is made at the flare of the base of the first metatarsal at the same angle.

With complete transection of the metatarsal, the bottom segment can be transposed laterally over one-third to one-half of the width of the metatarsal, correcting the metatarsus varus component of hallux valgus. If the PASA needs to be addressed, then the proximal portion of the plantar fragment is displaced slightly farther laterally. Temporary fixation is achieved by the use of a self-centering bone clamp, and permanent internal fixation is then completed using two 2.7- to 3.5-mm cortical screws. The screws are placed perpendicular to the osteotomy but angled slightly of center to obtain maximum bone purchase. The remaining cortex on the dorsal proximal fragment is then removed with a bone saw (Fig. 16-13).

The capsule and periosteum are reapproximated with 2-0 and 3-0 Dexon sutures. The subcutaneous tissue is reapproximated using 4-0 Dexon, and the skin is closed with material of the surgeon's choice.

Modifications to the Scarf Osteotomy

Incision

A more medial approach has been utilized to facilitate exposure of the plantar aspect of the first metatarsal, allowing the surgeon to release the lateral sesamoid apparatus through a plantar approach. The skin inci-

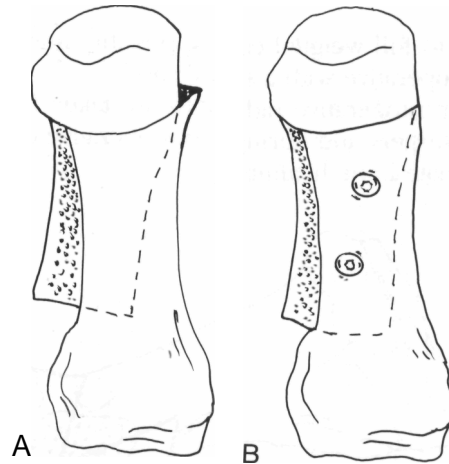


Fig. 16-13. Displacement of the Scarf osteotomy consists of two steps. (A) Lateral translation of the plantar segment; (B) proximal portion of the plantar segment is swiveled into the first interspace for PASA correction.

sion made over the medial to dorsomedial aspect of the first metatarsal but dips down at the level of the first metatarsophalangeal joint.

Fixation

Permanent, internally threaded 0.062-in. Kirschner wires have been used to replace cortical screws. This method of fixation is relatively simple and very effective. Intrinsic stability in the design of the osteotomy provides that the metatarsal will possess most of the load shearing. Although threaded Kirschner wires do not provide interfragmentary compression such as does a cortical screw in the lag technique, threaded Kirschner wires have proven to maintain compression and the position of the osteotomy provided by the bone clamp.

Osteotomy Length

The short Z bunionectomy has an osteotomy cut of 2.5 to 3.0 cm in length and is utilized for the correction of hallux valgus with or without an increase in the PASA. This technique offers the surgeon good stability and correction, using internal fixation with minimal shortening and less extensive tissue dissection (Fig. 16-14).

Postoperative Management

The following stages follow the Scarf or Z osteotomy:

Partial to full weight-bearing is possible immediately postoperative with a surgical shoe.

Initial postoperative radiographs are taken following the surgery and during the postoperative course to evaluate bone healing.

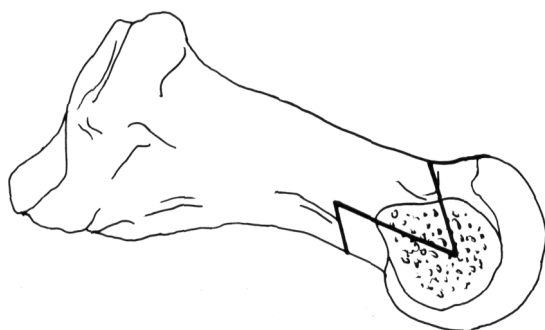


Fig. 16-14. Short Scarf or Z osteotomy.

Sutures are removed 1 week to 10 days postoperative. Patient returns to tennis shoes 3 to 4 weeks postoperative.

Patient can return to normal shoe gear 4 to 6 weeks postoperative if no complications occur.

Advantages and Disadvantages

The Scarf or Z osteotomy is another procedure that has found its place in the correction of hallux abducto valgus deformity with the advent of AO fixation techniques. The Scarf osteotomy depends on two maneuvers for correction: the lateral translational shift of the distal segment, and the swing of the plantar wing into the interspace for PASA correction. One should remember that PASA correction is made at the expense of intermetatarsal correction and that intermetatarsal correction is limited by the width of the shaft of the metatarsal. Troughing is seen if lateral displacement exceeds the cortical margins in the diaphyseal region of the bone, resulting in frontal plane rotation of the capital fragment. Fracture through the dorsal cortex at the proximal wing of the osteotomy can result from improper bone cuts or poor bone stock.

Rigid compression of the large bone-to-bone contact along with the inherent stability of the osteotomy provides a good environment for primary bone healing of the Scarf osteotomy. No casting is required, and the patient can ambulate immediately following this procedure, which makes the Scarf osteotomy desirable to both the patient and the surgeon. One should be aware that the Scarf osteotomy is a technically precise procedure and that familiarity with AO/ASIF fixation techniques, which are demanding, is essential.

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