

McGlamry's Comprehensive Textbook of Foot and Ankle Surgery

Third Edition

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CHAPTER 16

Proximal Procedures of the First Ray

PART 1

Osteotomies of the First Metatarsal Base

Robb A. Mothershed

Metatarsus primus adductus, or an increase of the first intermetatarsal angle, has long been recognized as a major contributing factor in the deformity of hallux abducto valgus. This component of hallux abducto valgus has been addressed by proximal osteotomies for decades. A transverse plane osteotomy of the first metatarsal base for the repair of hallux abducto valgus deformity was first described in 1901 by Loison (1), and it was performed in 1903 by Balacescu (2). However, not until the late 1960s and early 1970s did the base wedge osteotomy become popular and widely used. Over the intervening years, this particular procedure has been performed with less frequency because of several factors. First, certain complications were believed to be inherent to the procedure, including first metatarsal elevatus, shortening of the metatarsal, failure of the fixation, and delayed union (3-7). However, surgeons subsequently began to appreciate that most of these problems resulted from surgical technique, inadequate fixation, and insufficient postoperative protection, as opposed to a deficiency of the procedure itself. The perceived complications associated with the closing base wedge osteotomy also led surgeons to consider other forms of proximal osteotomies such as the crescentic and chevron configurations. In addition, other surgeons have employed more distal procedures for the correction of hallux abducto valgus deformity such as the Austin or Scarf osteotomies whenever possible. These latter procedures may prove technically easier to perform, and the patient can remain weight bearing during the postoperative period. However, the proximal osteotomies still are effective, particularly in patients with severe deformities and in patients with high intermetatarsal angles. The technical advances in surgical technique, rigid internal fixation, and the institution of a

non-weight-bearing interval in the postoperative recovery have demonstrated that these procedures can provide consistently good results.

INDICATIONS

Large Intermetatarsal Angles

The traditional indication for a transverse plane base osteotomy of the first metatarsal was a hallux abducto valgus deformity with a high intermetatarsal angle, typically exceeding 15 degrees. This is still a reasonable criterion for employing this type of procedure, although in some instances adequate correction of severe deformities can be accomplished with other approaches as well.

The base wedge procedure may be more effective in reducing a high intermetatarsal angle than a distal procedure, particularly in rigid deformities, because of the geometric principles of placement of the osteotomy (8). The oblique orientation of the base wedge osteotomy is angled from proximal-medial to distal-lateral. This design allows the axis and hinge of the osteotomy to be placed in close proximity to the base of the first metatarsal. The effect creates the longest distance possible between the hinge and the distal end of the bone while keeping the osteotomy within the first metatarsal. This distance is the radius arm. A longer radius arm creates greater lateral movement at the end of the arm for each degree of rotation around the arc of the circle. Therefore, the base wedge osteotomy allows greater lateral movement of the head of the metatarsal for every degree of wedge resected and thereby provides a more effective procedure.

In addition, the more proximal the apex of the osteotomy,

the more lateral is the axis of rotation in relation to the position of the second metatarsal. Therefore, a more proximal hinge provides a more lateral overall position of the first metatarsal head once the distal segment has been reduced into a parallel relationship with the second metatarsal. In effect, the more proximal hinge allows the first metatarsal head to come closer to the second metatarsal without creating a negative intermetatarsal angle in the distal segment of the bone (8).

The crescentic osteotomy also offers a more proximal location for rotation of the metatarsal. Although the proximal chevron procedure is typically transposed, it may also be rotated to enhance the reduction of the intermetatarsal angle. In each instance, more effective correction of large intermetatarsal angles may be obtained as compared with distal osteotomies.

Rigid First Ray

Flexibility of the first ray is an important factor to consider when evaluating the patient with hallux abducto valgus deformity. The success of a distal metatarsal osteotomy in the repair of hallux abducto valgus deformity associated with high intermetatarsal angles requires good transverse plane flexibility. This feature may be evaluated preoperatively by assessing the sagittal plane mobility of the first ray. If the

first ray demonstrates good mobility in the sagittal plane, then it will almost always have good mobility in the transverse plane as well. In addition, one may assess the flexibility by applying medial to lateral compression to the first metatarsal head. However, if the sesamoids are significantly displaced within the first intermetatarsal space, then lateral shift of the metatarsal head may be difficult to accomplish.

Radiographic evaluation may also render helpful information. Some patients may actually have an enlarged articular facet between the metatarsal bases and a rudimentary os intermetatarsia, both of which are typically associated with less mobility of the first ray (Fig. 1). When distal osteotomies are employed for the correction of greater degrees of hallux abducto valgus deformity, the correction is accomplished by a combination of the release of soft tissue tension about the first metatarsal phalangeal joint and the translocation of the metatarsal head. If a distal osteotomy is performed in a rigid deformity, then the release of the soft tissues at the first metatarsophalangeal joint will generally result in little if any ability to reduce the intermetatarsal splay significantly. As such, it becomes more difficult to achieve a desirable permanent correction with a distal procedure. Therefore, a proximal osteotomy may be appropriate for correction of the hallux abducto valgus deformity in patients with reduced mobility of the first ray with only moderate amounts of intermetatarsal splay.

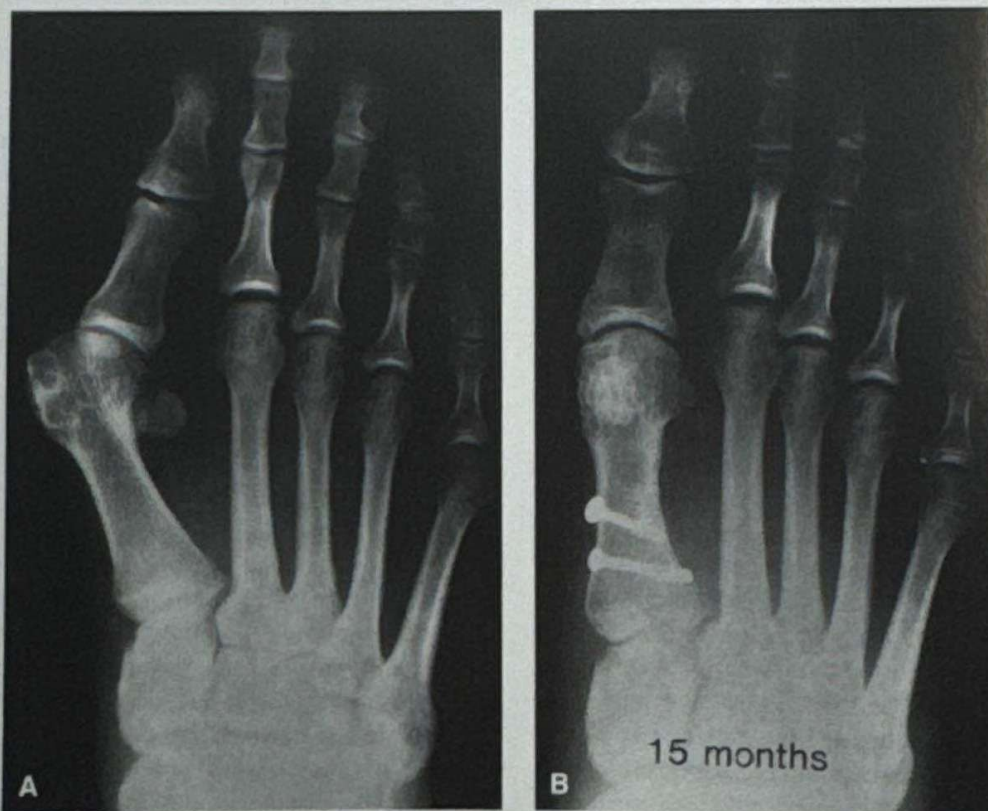


FIG. 1. A: Preoperative radiograph of a patient with severe hallux abducto valgus and a rigid first ray secondary to the articular relationship of the first and second metatarsal bases. B: Postoperative appearance 15 months after a closing base wedge osteotomy and fibular sesamoidectomy.

Sagittal Plane Abnormalities of the First Ray

Proximal osteotomies may also be helpful in addressing significant sagittal plane deformity or disease in patients with hallux abducto valgus deformity. The presence of a callus or pain plantar to the second metatarsal head generally indicates a hypermobile first ray, and patients may benefit from simultaneous plantarflexion of the metatarsal with reduction of the intermetatarsal angle. Proximal osteotomies are well suited to correction of this type of combined deformity.

An abnormally large sagittal plane deviation of the metatarsal can be more effectively corrected with an osteotomy of the first metatarsal base. An elevated first metatarsal may be effectively addressed at the base of the metatarsal because there will be more effective plantarflexion of the metatarsal as the resection of a small amount of bone wedge at the base translates into a larger amount of plantar deflection of the metatarsal when compared with resection of a distal wedge of bone. If a similar amount of plantarflexion could be achieved with a distal metatarsal osteotomy, it would more abruptly change the vectors of the flexor and extensor tendons crossing the joint. This change in vectors would potentially have a greater disruption of the muscular balance of the first metatarsal phalangeal joint, which could lead to a recapturing or cock-up hallux.

Hallux Abducto Valgus with Metatarsus Adductus

Some investigators have described the association of hallux abducto valgus with metatarsus adductus. LaReaux and Lee found that 35% of their patients with hallux abducto valgus had a metatarsus adductus deformity, compared with only 13% in a control group (9). Measurements of radiographs in 115 feet without evidence of hallux abducto valgus demonstrated a statistically significant and direct relationship between an increasing metatarsus adductus angle and an increasing hallux abductus angle (10). Banks et al. noted, in their series of patients with juvenile hallux abducto valgus, that 48 of the 72 cases had a metatarsus adductus angle greater than 15 degrees (11). Furthermore, an association was noted between an increasing metatarsus adductus angle and increasing amounts of hallux abductus.

The initial radiographic evaluation of hallux abducto valgus in patients with a concomitant metatarsus adductus is often misleading. Significant abduction of the hallux may be noted, yet with little intermetatarsal splay (Fig. 2). However, one must consider that the generalized adductus of the forefoot results in a greater functional value of the intermetatarsal angle. In this situation, the true intermetatarsal angle may best be estimated by the following formula (12):

$$\text{True intermetatarsal angle} = (\text{Metatarsus adductus angle} - 15 \text{ degrees}) + \text{Intermetatarsal angle}$$

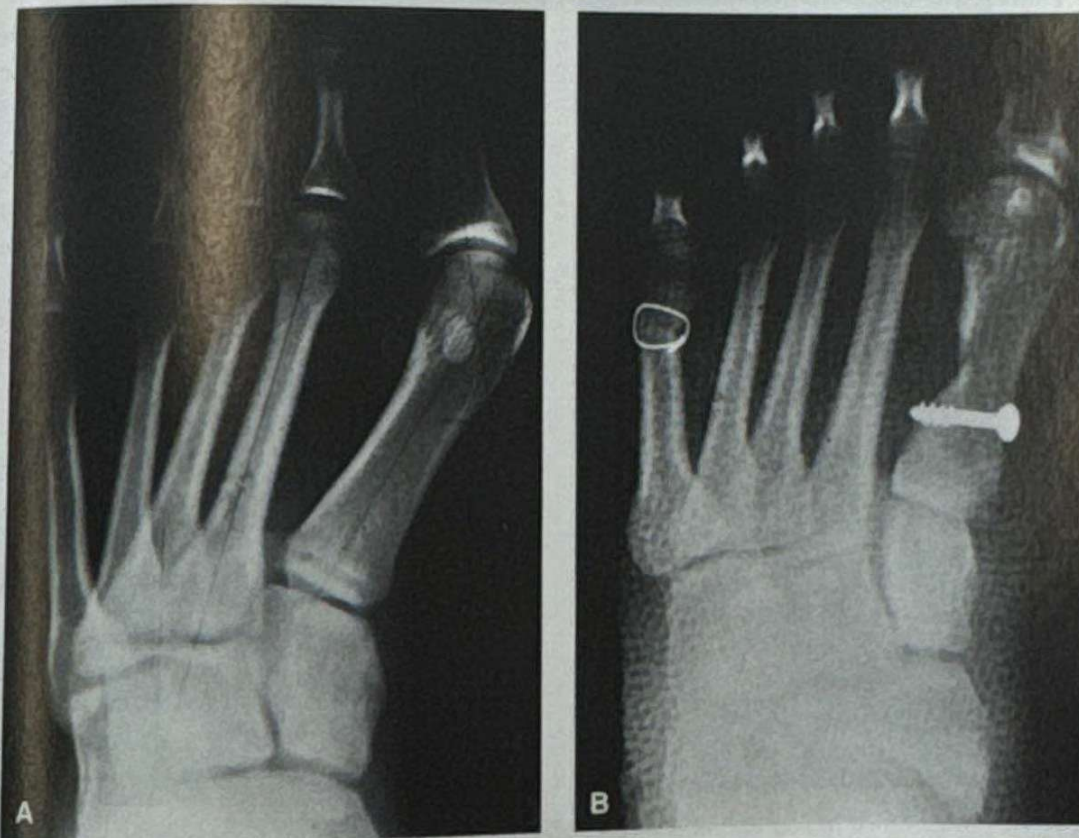


FIG. 2. **A:** A preoperative radiograph of a patient with hallux valgus deformity with concomitant metatarsus adductus. **B:** A closing base wedge osteotomy was performed to reduce the first intermetatarsal space.

This formula provides a better determination of the actual intermetatarsal angle being treated.

When repairing a hallux abducto valgus deformity in a patient with metatarsus adductus, the surgeon should reduce the intermetatarsal angle to 0 degrees or a slightly negative value to minimize the chance of recurrence of hallux abducto valgus (12). Despite excellent correction, the hallux may not remain perfectly rectus, but it may resume a slightly abducted alignment postoperatively. The longer radius for correction with a proximal osteotomy is well suited to achieve the degree of correction that is desirable.

Juvenile Hallux Abducto Valgus Deformity

The development of a hallux abducto valgus deformity in young patients represents significant deforming forces acting on the foot. Patients with juvenile hallux abducto valgus often present with other significant deformities. Banks et al. found that 66.7% of their patients with juvenile hallux abducto valgus deformity possessed a metatarsus adductus angle greater than 15 degrees (11). Pes valgus deformity and ankle equinus have also been associated with juvenile hallux abducto valgus (12–15).

In the younger patient, correction of hallux abducto valgus deformity must be maintained over decades. Studies have

shown that the incidence of recurrence of the deformity is higher in young patients undergoing a soft tissue procedure or distal osteotomy (16–18). The intermetatarsal angle in juvenile and adolescent patients is best reduced to 0 degrees or closely approximating that value to minimize the possibility of recurrence. In most patients, this goal can be more effectively accomplished with a proximal osteotomy.

Iatrogenic Deformities

Correction of a recurrent hallux abducto valgus deformity often represents a difficult challenge. The metatarsal head is typically narrowed from the previous surgical procedure, and this configuration may make the use of a capital osteotomy difficult for the degree of correction required (Fig. 3). Furthermore, the presence of any retained fixation devices may compromise the integrity of the bone, so additional osteotomies at this level may pose more of a risk relative to fixation. In these instances, a proximal osteotomy may prove the best alternative, even if the intermetatarsal angle is low.

ANATOMIC CONSIDERATIONS

The choice of incisions for proximal osteotomies has been debated, but an effective incision may be placed dorsally

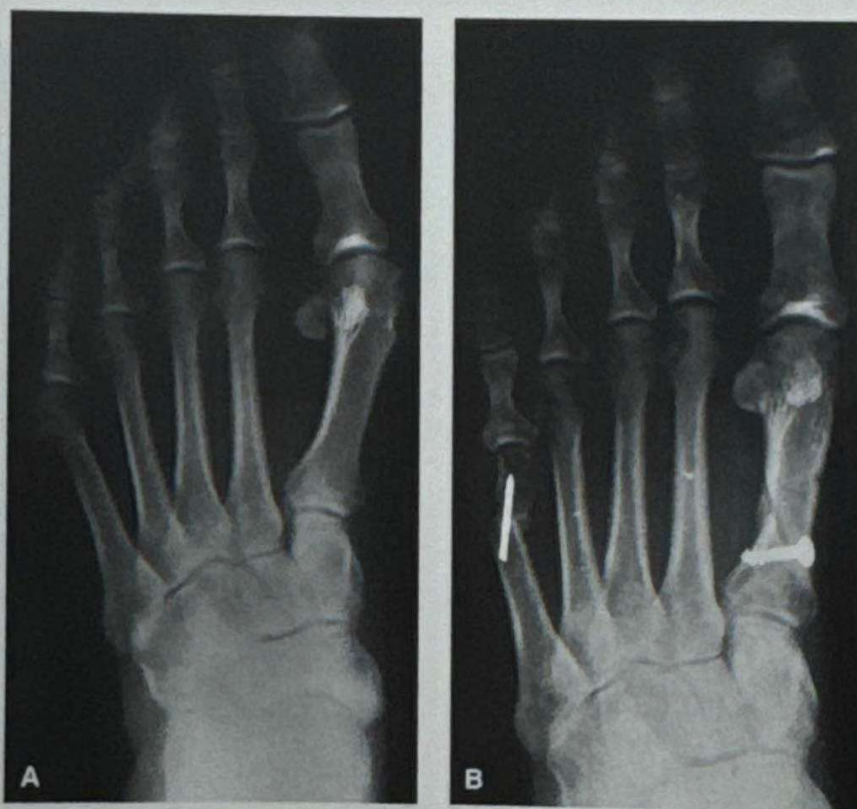


FIG. 3. A: Preoperative radiograph of a patient after a simple Silver bunionectomy with narrowing of the metatarsal head. This may preclude the use of a capital osteotomy for subsequent repair. B: Radiograph after a closing base wedge osteotomy.

idence of recurrence of the deformity is patients undergoing a soft tissue procedure (16-18). The intermetatarsal angle in recent patients is best reduced to 0 degrees, meaning that value to minimize the possibility. In most patients, this goal can be more easily achieved with a proximal osteotomy.

ities

recurrent hallux abducto valgus deformity is a difficult challenge. The metatarsal head removed from the previous surgical procedure, may make the use of a capital osteotomy. The degree of correction required (Fig. 3). The presence of any retained fixation devices may compromise the integrity of the bone, so additional level may pose more of a risk relative to distances, a proximal osteotomy may prove useful, even if the intermetatarsal angle is low.

NSIDERATIONS

considerations for proximal osteotomies has been effective incision may be placed dorsally



nectomy with narrowing of subsequent repair. B: Radio-



FIG. 4. Once the first metatarsophalangeal joint dissection has been accomplished, the skin incision is extended proximally for execution of the base osteotomy.

along the first ray slightly medial to the extensor hallucis longus tendon. The incision commences proximal to the first metatarsocuneiform joint and extends distally to the proximal phalanx. Typically, the distal segment of the incision is initiated and the metatarsophalangeal joint is released, and then the incision is extended proximally to provide access for the osteotomy (Fig. 4). The single-incision approach has been employed for decades without deleterious sequelae (8).

Once the skin incision is completed, dissection is carried through the relatively thin subcutaneous tissues. The previously defined tissue planes may be followed from the more distal aspect of the wound into the proximal metatarsal area. At the proximal aspect of the incision, one typically encounters a branch of the medial dorsal cutaneous nerve. This nerve is easily retracted into the medial subcutaneous tissues. Once the superficial fascia has been cleared from the deeper structures, the deep fascia is incised along the medial aspect of the extensor hallucis longus tendon. This provides for effective retraction of the tendon and better exposure of the base and shaft of the metatarsal. The periosteum is then incised and reflected from the base of the metatarsal. Additional dissection of this layer may be required both medially and laterally to allow satisfactory clearance for the saw blade during the performance of the osteotomy as well as the insertion of internal fixation.



FIG. 5. The transverse closing base wedge osteotomy.

TECHNIQUES

Closing Base Wedge Osteotomy

The closing wedge osteotomy has been the standard technique for base procedures for many years. Traditionally, the procedure was performed in a transverse orientation, and fixation was provided by Kirschner wires (K-wires), intraosseous wire loops, or other methods (Fig. 5). The transverse wedge osteotomy was modified to an oblique orientation to accommodate screw fixation (8) (Fig. 6). In addition, the oblique orientation allows the surgeon to place the apex of the osteotomy further proximally, thus providing a longer radius arm for correction. More freedom was obtained in

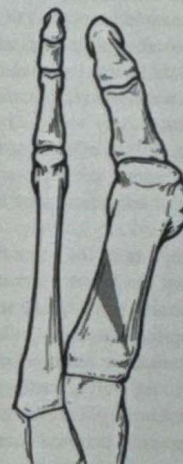


FIG. 6. The oblique closing base wedge osteotomy.

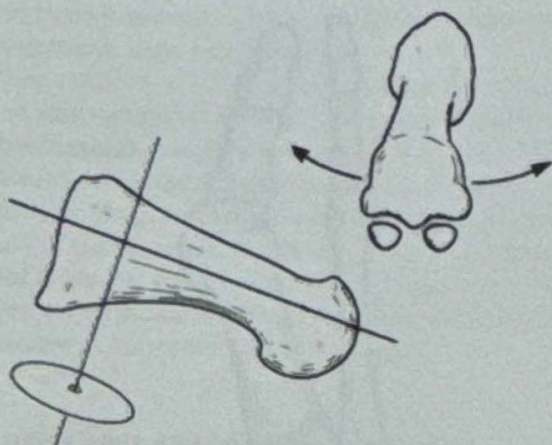


FIG. 7. Traditional axis of the base wedge osteotomy. If the osteotomy is made perpendicular to the metatarsal, subsequent lateral displacement of the distal metatarsal will result in sagittal plane dorsiflexion as well. Such may be the cause of a short first metatarsal.

maneuvering the oscillating saw for performance of the procedure. With this technique, the handle of the saw is directed medially away from the foot and is free from the interference and contact of the foot itself. Therefore, the surgeon need not worry that the saw may be misdirected during the osteotomy.

Regardless of which orientation is employed, the use of an axis guide may facilitate the performance of the osteotomy. The axis guide also provides an accurate means of assessing and implementing concomitant dorsiflexion or plantarflexion of the distal metatarsal with closure of the osteotomy. During the base wedge osteotomy of the first metatarsal, an intact cortical hinge acts as an axis of rotation (8). The traditionally perceived axis for a hinged osteotomy of the first metatarsal was perpendicular to the long axis of the bone. Because of the anatomic declination of the first metatarsal in the human foot, rotation of the distal segment of the first metatarsal around this axis after a closing base wedge osteotomy would tend to create elevation of the metatarsal head from the weight-bearing surface (Fig. 7). However, designing the osteotomy so the axis is perpendicular to the weight-bearing surface allows for full rotation of the distal segment of the metatarsal without elevating or plantarflexing the metatarsal head in relation to the weight-bearing plane (Fig. 8).

The previous description of the sagittal plane orientation of the axis is based on the given relationship that the axis is perpendicular to the transverse plane when viewed in the frontal projection. Logically, manipulation of the axis in the frontal plane may influence the ultimate position of the metatarsal head in relation to the weight-bearing surface. Manipulation of the axis in the frontal plane is based on the presumption that the axis remains perpendicular to the weight-bearing surface in the sagittal plane.

With the axis perpendicular to the weight-bearing surface in the frontal plane, lateral rotation of the distal metatarsal

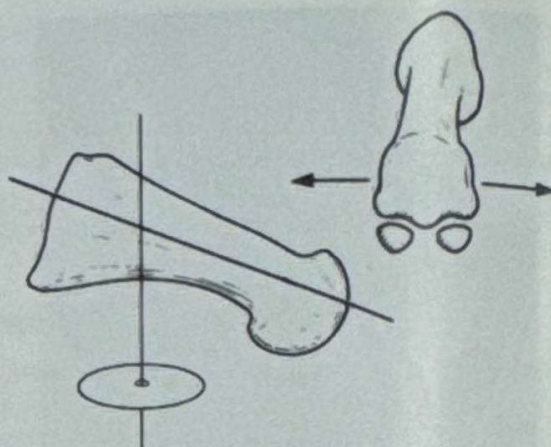


FIG. 8. If the osteotomy is made perpendicular to the weight-bearing surface, then lateral displacement of the distal metatarsal will not dorsiflex or plantarflex the metatarsal head, and it should remain parallel with the weight-bearing surface.

segment maintains the metatarsal head on the weight-bearing surface (Fig. 9). When the superior pole of the axis is tilted laterally, a dorsomedial hinge is created, and plantarflexion of the distal segment of the metatarsal occurs with lateral rotation or closing of the wedge osteotomy (Fig. 10). Conversely, when the superior pole of the axis is tilted medially, a plantar medial hinge is created, and dorsiflexion of the distal segment occurs with closing of the wedge osteotomy (Fig. 11).

The concept of the axis relationship just described may be directly applied to the actual execution of the closing base wedge osteotomy of the first metatarsal. A 0.045-inch K-

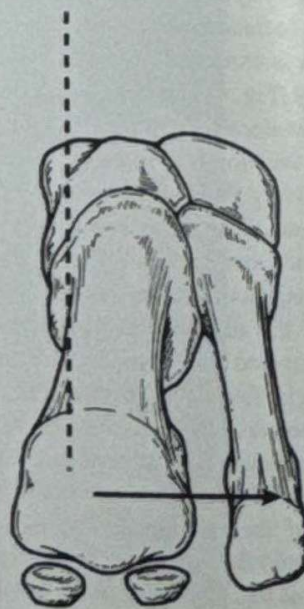


FIG. 9. Proper frontal plane orientation must be observed as well. Same perpendicular relationship of the axis is essential if the distal segment is to remain on the weight-bearing surface after closure of the osteotomy.



FIG. 10. Altering the position of the axis may be used to the surgeon's advantage. If the axis is tilted laterally, then a dorsomedial hinge is created. When the osteotomy is closed, plantarflexion of distal segment occurs.

wire can be drilled through the base of the first metatarsal to represent the functional hinge of the intended osteotomy. The K-wire should penetrate the dorsal cortex just short of the apex of the intended osteotomy, to allow for additional feathering of the hinge. The wire is then drilled to penetrate the metatarsal at the appropriate angle, which affects manipulation of the distal metatarsal as required for each individual case.

With the K-wire in place, the relationship of the axis with the weight-bearing surface is evaluated from a medial and frontal perspective. The position of the axis may easily be changed before the osteotomy by simply removing and reinserting the K-wire.

The wedge osteotomy is then cut by keeping the plane of



FIG. 11. Should dorsiflexion of the distal segment be necessary, then the axis should be tilted medially.

the saw blade in line with the axis guide so the planes of the two cuts converge at the K-wire. The medial cortex of the metatarsal remains intact as a physical hinge that coincides with the axis and planes of the intersecting wedge osteotomies. The osteotomy may be feathered to create a flexible yet intact hinge that bends but does not fracture with manual reduction. Christensen et al. showed that the intact medial hinge provides stability to the osteotomy and functions as another point of fixation (19). If the hinge fractures, the stability of the osteotomy will be reduced, and fixation may prove more difficult.

Various forms of fixation have been employed with the closing base wedge osteotomy, and studies have been conducted in an attempt to determine which form of fixation is more stable (20,21). An important factor for a successful closing base wedge osteotomy is the presence of two points of fixation. An intact medial cortical hinge may be considered one point of fixation. The transverse wedge osteotomy is more commonly stabilized with crossed K-wires or cerclage wire. Evidence seems to indicate that when a K-wire is used, the osteotomy is more stable if the wire crosses the metatarsal-cuneiform joint (21). Cerclage wire appears to provide the most stability when it is applied at the plantar aspect of the metatarsal, such that it prevents disruption by the weight-bearing forces (20).

Although K-wires and cerclage wire are commonly used for fixation, the technique I favor is the use of two 4.0-mm partially threaded cancellous screws to secure the osteotomy. This has provided effective fixation and a high rate of success. The first screw is placed distal to the medial hinge and is oriented perpendicular to the metatarsal. The second screw is positioned distal to the first and is oriented perpendicular to the osteotomy (Fig. 12). Alternatively, crossed-screw fixation of the base wedge has been described, with favorable results (22). The cancellous screws are employed more often because they provide rigid fixation of the osteotomy, regardless of the integrity of the bone. However, provided non-weight-bearing is instituted after surgery, both crossed 0.062 K-wires and a single screw may provide good results that are comparable (23). Cortical bone screws also provide good stabilization.

The closing base wedge osteotomy has always been an effective means of reducing the intermetatarsal angle, although early reviews noted that shortening of the first metatarsal was a common occurrence after a transverse base wedge osteotomy (3-7). As a consequence, metatarsalgia, painful plantar callosities, and stress fractures of the lesser metatarsals developed in some patients. However, the base wedge osteotomy was not totally abandoned because it provided a much needed alternative in patients with severe deformities with high intermetatarsal angles. A few workers persisted in the investigation of the procedure (24), and the technical aspects were further advanced by the application of rigid internal fixation across angulated osteotomies. However, elevation of the first metatarsal continued to develop even with the use of the new fixation

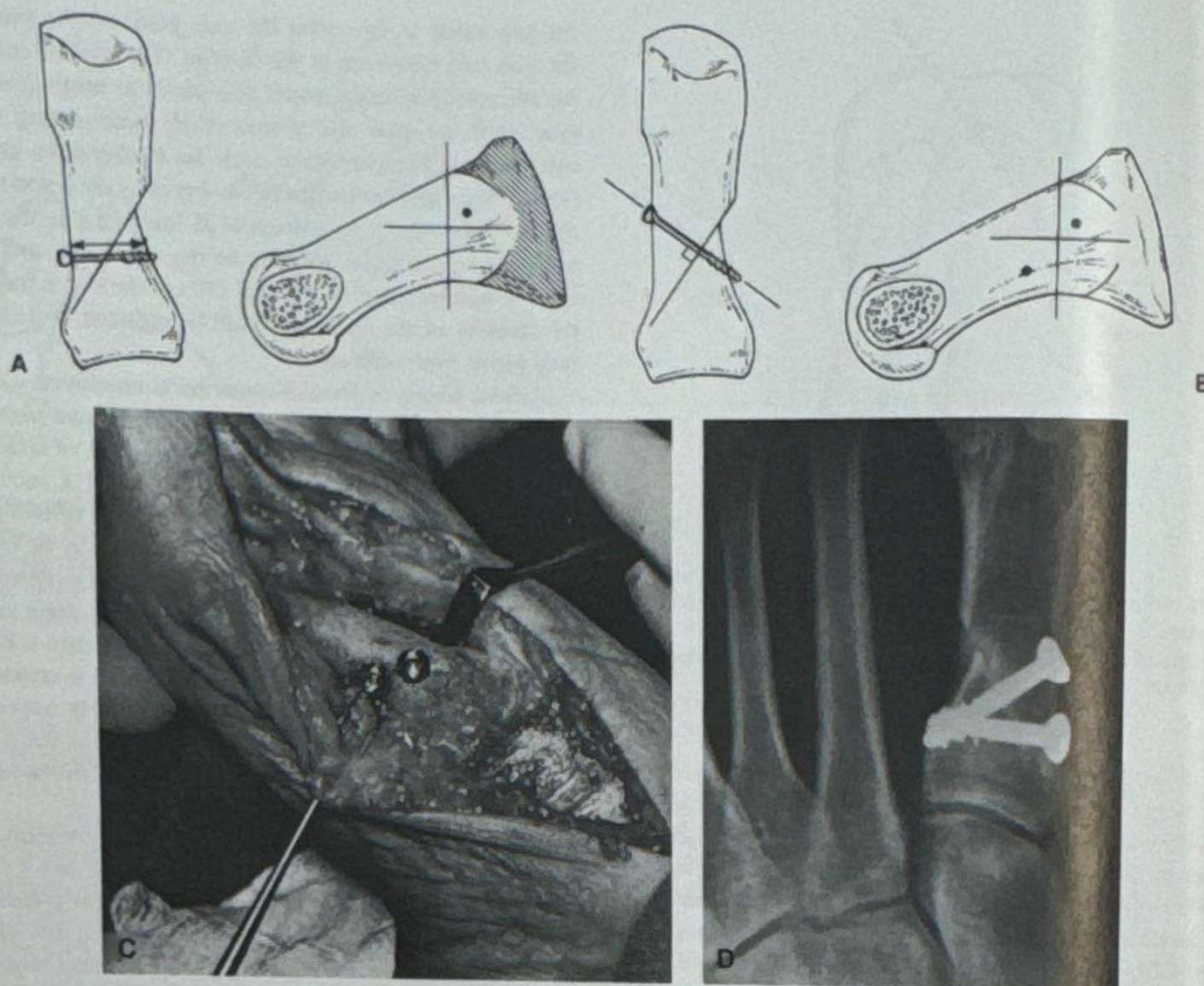


FIG. 12. Two-screw fixation for the oblique closing base wedge osteotomy. **A:** The anchor screw is oriented perpendicular to the medial cortex or long axis of first metatarsal. **B:** Compression screw perpendicular to the plane of the osteotomy. **C:** Medial orientation of the two-screw technique. **D:** Compression and anchor screws.

techniques. Although some authors proposed that the change in metatarsal declination was related to the removal of excessive amounts of bone from the dorsal aspect of the osteotomy (6), Schuberth et al. attributed this phenomenon to weight bearing in the postoperative period before osseous healing had occurred, as opposed to its being a primary complication of the procedure itself (7). Furthermore, the radiographic appearance of a shortened metatarsal could largely be explained by the elevation of the distal fragment, which could be overcome by geometrically correct osteotomy and an appropriate interval of non-weight-bearing during the healing process (8). Later investigators proved that the shortening associated with the oblique base wedge osteotomy was less than actually perceived. Using both mathematic and bone models, investigators determined that the average oblique base wedge osteotomy would result in less than 2 mm of shortening, comparable to most other osteotomies (25). Therefore, elevation of the first metatarsal would be a primary means

of creating the appearance of a "shortened" metatarsal on dorsoplantar radiographs. Other investigators noted that early weight bearing in the postoperative period either contributed to or directly caused failure of the fixation (26).

However, later authors who instituted at least 6 weeks of non-weight bearing after the closing base wedge osteotomy continued to find evidence of first metatarsal elevation, although of far less magnitude and with few associated problems (19,27,28). Nonetheless, patient satisfaction rates were high, and evaluations of the results by the investigators were similar. The problems of transfer lesions or other symptoms related to the alignment of the first ray were minimal. In one study, 44% of patients admitted to premature weight bearing on the extremity (28). Whether this is a consistent finding in other patient groups or whether this accounts for the small degree of metatarsal elevation is unknown. In addition, an inconsistency is noted in the means by which first metatarsal elevation has been measured on radiographs, and

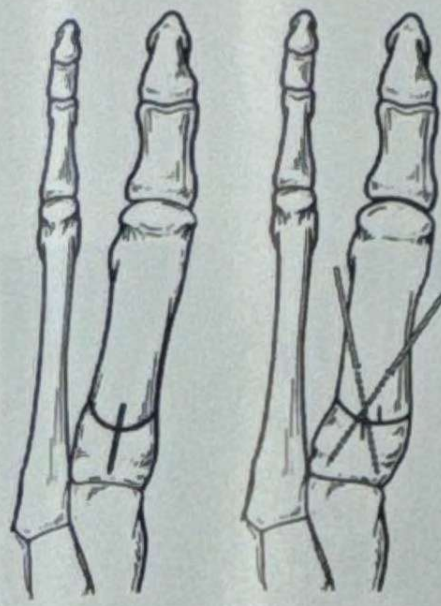


FIG. 13. A,B: The crescentic first metatarsal osteotomy. A notch may be made on each side of the osteotomy before rotation to help assess the amount of correction achieved.

at times the values could have been affected by the position of the foot. Therefore, it appears that at the current levels of elevation noted with non-weight bearing in the postoperative setting, this phenomenon is clinically inconsequential. Good correction can be achieved with restoration of function.

Crescentic Osteotomy

The crescentic osteotomy is another popular technique for achieving reduction of the intermetatarsal angle at the proximal aspect of the first metatarsal. This procedure may provide correction of deformity in all three planes (Fig. 13). Because no bone is resected, this procedure theoretically produces little shortening (29), so it may be a good alternative in the patient who has a significantly short first metatarsal. However, the performance of any osteotomy creates some amount of shortening, typically in the range of 1 to 2 mm. The osteotomy has been modified to include a plantar shelf in an attempt to provide more stability (30).

A special crescentic blade is necessary to perform the procedure. The saw blade is oriented with the concavity directed proximally, so there is more excursion of the bone segments to allow for correction of the intermetatarsal angle. This also allows for better bone contact once the osteotomy is rotated (31). Cohen et al. and Kay et al. demonstrated how the orientation of the blade directs the correction in each plane (29,30). As in the closing base wedge osteotomy, the cut should be oriented so the saw is perpendicular to the weight-bearing surface to prevent dorsiflexion of the distal metatarsal with lateral rotation. If the blade is oriented lat-

erally, then plantarflexion of the distal segment will occur, with reduction of the intermetatarsal angle. If the blade is oriented medially, then dorsiflexion will occur with translation of the osteotomy.

The osteotomy is best performed distal to the plantar flare of the metatarsal; otherwise, the cut will be difficult to complete. A small notch may be made at the intended osteotomy site, to provide a better determination of the amount of correction that is achieved with rotation of the distal segment (Fig. 14). However, care must be taken not to produce significant plantarflexion and inversion during correction of more severe deformities. It appears that the best correction of the intermetatarsal angle may be achieved when the saw diameter is larger than the diameter of the osteotomy site (31).

Although the crescentic osteotomy does provide good correction, it has some disadvantages. Because there is no fixed hinge, the osteotomy is unstable, and this feature may make it difficult to achieve solid, reliable fixation across the osteotomy site. The cannulated screw system has facilitated this process (32). Fixation may consist of one screw (33,34), two screws (32), one screw and one K-wire (35), crossed K-wires, or Steinmann pins. The screws can become prominent at a later time and may require removal (33).

Cohen et al. described a modification of the crescentic procedure that incorporated a plantar shelf to enhance overall stability (30). A K-wire was introduced medially at the apex of the osteotomy, and the plantar shelf was created initially with a sagittal saw. The dorsal crescentic cut was then performed. Good results were noted without sagittal plane deviation of the first metatarsal. Later studies comparing the crescentic shelf and standard crescentic procedures indicated that, by using the shelf procedure, one could produce slightly greater reductions in the intermetatarsal angle and enhanced plantarflexion of the distal metatarsal, although the differences were not statistically significant. Overall, both procedures possessed similar mechanical properties, although investigators believed that the shelf osteotomy may be easier to fixate (36).

Favorable results have generally been reported with the procedure (30,32–35,37). Although the crescentic osteotomy may tend to resist sagittal plane disruptive forces more effectively than a base wedge osteotomy (38), weight bearing cannot be recommended before osseous consolidation. Unrestricted weight bearing has been associated with metatarsal elevation (33–35), although most authors have apparently not altered their postoperative regimen to prevent this potential problem.

Chevron Osteotomy

The procedure was first described by Kotzenberg in 1929 as a horizontal "V" in Schotte's article (39). The osteotomy is performed 1 to 1.5 cm from the metatarsal cuneiform joint. The apex of the osteotomy can be oriented either distally or proximally, although most surgeons appear to favor a distal



FIG. 14. A: The crescentic osteotomy is performed with the concavity directed proximally. B: A crescentic osteotomy is temporarily fixated with a guidewire for a cannulated screw. C: A preoperative radiograph of a patient with a high intermetatarsal angle. D: After the crescentic osteotomy and fixation with two cannulated screws. (Courtesy of Ira Fox, D.P.M.)

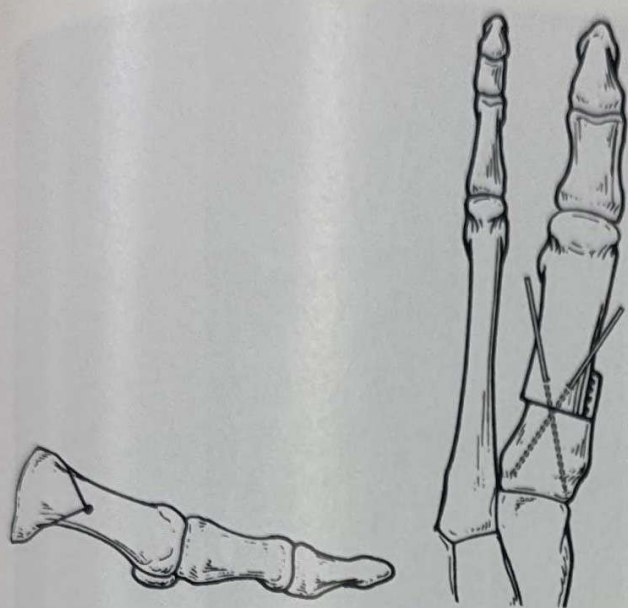


FIG. 15. A,B: The proximal chevron osteotomy.

apex. In either instance, care should be taken to avoid compromise of the first metatarsal cuneiform joint (Fig. 15). The same axis guide techniques described for osteotomies of the metatarsal head may be incorporated into the proximal procedure to shorten, lengthen, dorsiflex, or plantarflex the distal metatarsal with lateral transposition. However, because the osteotomy is primarily transpositional, it does not appear to provide any advantage over the more distally based Austin procedure. Regardless of the location of the osteotomy, similar amounts of lateral shift result in similar reductions in the intermetatarsal angle. Improved correction may be achieved with the proximal chevron procedure if the distal segment is swiveled laterally before fixation. The design of the osteotomy affords good stability in the sagittal plane.

One may experience some difficulty in securing fixation. The V-osteotomy may be stabilized with one (40) or two screws, or a single (34) or crossed K-wires (35). In some instances, the screw may have to traverse the tarsometatarsal joint to achieve adequate stability (40).

Favorable experiences have been reported with the procedure, and few complications have been noted (34,40). Dorsal angulation of the first metatarsal has been noted in some patients (34). Although weight bearing has been allowed in the postoperative setting, it cannot be recommended.

Opening Base Wedge Osteotomy

The opening base wedge osteotomy is seldom performed today because of the increased technical demands of the procedure. A primary indication is an excessively short first metatarsal resulting from iatrogenic or congenital causes. The hinge is laterally based, and a bone graft is placed in the osteotomy site to achieve correction by expanding the

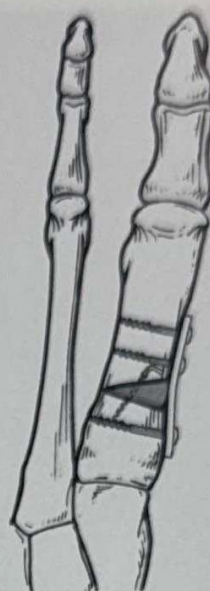


FIG. 16. The opening wedge osteotomy. A laterally based hinge is necessary for this procedure.

medial side of the metatarsal (Figs. 16 and 17). Graft can be harvested from many possible donor sites in the foot, leg, or hip. The medial eminence from the metatarsal head is often used because it is readily accessible (41). However, in some instances, the quality of bone from this area is not optimal and has been associated with loss of correction with time (42).

The opening base wedge osteotomy has an increased healing time because of the time required for the graft to incorporate into the metatarsal. The use of a graft also increases the risk of delayed union or nonunion. Furthermore, at times one may note a delayed shift in the alignment of the distal metatarsal. Fixation may be provided with crossed K-wires, cerclage wire, plates and screws, staples (41), or external fixation (43), although originally this osteotomy was not fixated (44), and other surgeons have allowed weight bearing in a cast without fixation (42). Youngswick recommended that the osteotomy be performed, the metatarsal rotated to the corrected position, and staple fixation applied prior to the insertion of the bone graft (41).

The purpose of the opening wedge osteotomy is either to lengthen or to prevent shortening of the metatarsal, although this may predispose the patient to developing a hallux limitus or hallux rigidus deformity by increasing tension at the metatarsophalangeal joint. Curiously, few studies have actually evaluated the change in length after the procedure, although one series noted no significant change in the relative lengths of the first and second metatarsals at postoperative follow-up (42). If this finding is accurate, then it would appear to obviate the specific indication for the opening wedge osteotomy compared with other proximal procedures, especially considering the additional risks and complexities of the former.

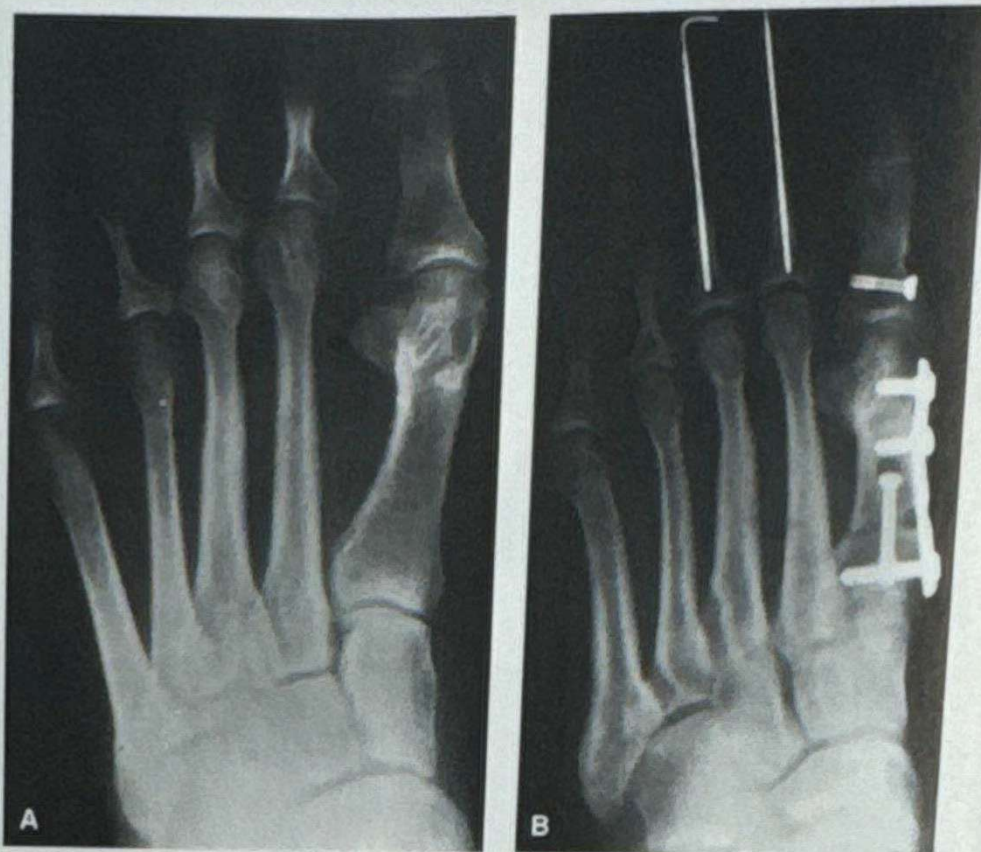


FIG. 17. **A:** A patient with recurrent hallux abducto valgus deformity and a short first metatarsal. **B:** After an opening base wedge osteotomy. Stabilization was achieved with a plate and screw.



FIG. 18. **A,B:** Elevation of the first metatarsal may develop after any proximal first metatarsal if weight bearing is allowed before healing.



FIG. 19. A,B: Nonunion of the first metatarsal base resulting in part from early weight bearing. C: The nonunion was resected, and a bone graft was obtained from the patient's iliac crest to preserve length to the metatarsal.

POSTOPERATIVE COURSE

Proximal osteotomies must be protected against the disruptive forces of weight bearing, regardless of the procedure or fixation. Although most distal osteotomy designs can withstand the forces of weight bearing, the base osteotomy can be easily disrupted by the forces transmitted through the longer lever arm (Fig. 18). Once the internal fixation is compromised, instability of the osteotomy will occur, producing motion and ultimately elevation of the first metatarsal. If the disruptive forces continue across the osteotomy site, a delayed union or nonunion can develop (Fig. 19). Non-weight bearing is maintained for a minimum of 6 weeks and until evidence of bone healing is sufficient. The patient is placed in a below-knee non-weight-bearing cast, and ambulation is assisted with crutches, walker, or a knee walker. Early passive range of motion of the first metatarsal phalangeal joint can begin even during the casting period.

The range-of-motion exercises can also be performed at the lesser metatarsal phalangeal joints and the knee. After 6 weeks, the patient can usually progress to protective weight bearing, provided the patient has radiographic evidence of osseous healing and satisfactory clinical evaluation.

SUMMARY

Base osteotomy of the first metatarsal can be a successful and rewarding component of hallux valgus surgery. Many advances have been made in the technical aspects of these procedures, such as precise resection of bone and stable fixation techniques that have accounted for fewer complications and improved results. The use of the hinge-axis concept can aid in the proper orientation of the osteotomy. Once the osteotomy is temporarily fixated, one should evaluate the patient's foot to ensure that the proper amount of correction

has been achieved. It appears that subsequent elevation of the first metatarsal has been noted with all these procedures, although the outcomes achieved would lead one to believe that this is not a functional problem with the amount of displacement currently observed.

In all osteotomies of the first metatarsal base, stable fixation is important to ensure a successful result. Although studies may indicate that one form of fixation is superior to another for any given procedure, in actual clinical practice, these differences often prove insignificant, provided good correction is achieved and appropriate measures are instituted after surgery. Regardless of which procedure is performed, the patient must remain non-weight bearing for a minimum of 6 weeks and until bone healing is sufficient. Osteotomy of the first metatarsal base provides predictable long-term results in a reliable manner in the compliant patient, especially when careful attention is paid to the technical aspects of its execution.

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PART 2

Metatarsal Cuneiform Procedures

Alan R. Catanzariti and Edwin L. Blich IV

FIRST METATARSOCUNEIFORM ARTHRODESIS

Procedures involving the first metatarsocuneiform joint have been advocated since the earliest stages of hallux valgus repair. The initial impetus for surgical intervention at this site was based on what was believed to be the primary cause of hallux abducto valgus (1-3). Truslow described hallux abducto valgus as secondary to a "metatarsus primus varus," which would need to be addressed for surgical treatment to be successful. To accomplish this purpose, he favored a wedge resection from the first metatarsocuneiform joint (2). Kleinberg believed that the most remarkable finding on a dorsoplantar radiograph in patients with hallux abducto valgus was the adduction of the first metatarsal. He noted that whereas the remaining tarsometatarsal joints were transverse, the first metatarsocuneiform joint was oriented in a more oblique manner. To correct the primary cause of the hallux abducto valgus, Kleinberg believed that one would be required to address the tarsometatarsal joint. Truslow's procedure was thought inadequate to reduce the deformity, and Kleinberg proposed a double wedge resection of the joint that would allow the first and second metatarsals to be oriented parallel to one another (3). Later, Lapidus described metatarsus primus varus as an atavistic foot type that had not fully developed over previous phylogenetic forms. Again, this increased separation between the first and second metatarsals was deemed the most frequent cause of hallux abducto valgus, and resection of the first metatarsocuneiform joint was advocated (4).

As the decades passed, the philosophies regarding the origin of hallux abducto valgus changed, yet resection of the first metatarsocuneiform joint remained an accepted procedure, albeit with a different perspective. Other indications have evolved, so arthrodesis of the first metatarsocuneiform joint remains a viable option in patients with hallux abducto valgus (Fig. 20).

Indications

In numerous instances, arthrodesis of the first metatarsocuneiform joint may prove an acceptable choice in the repair of hallux abducto valgus. Correction of large intermetatarsal angles may be readily accomplished; an intermetatarsal angle greater than 15 degrees has been an arbitrary level at which the procedure was deemed appropriate (5-7). However, the procedure may also be employed in patients with

lower intermetatarsal angles and concomitant metatarsus adductus or a long first metatarsal, to enhance first ray stability, in cases of revisional surgery, or in patients with degenerative change or symptoms at the first metatarsocuneiform joint. Arthrodesis at this level may also be helpful in addressing hallux rigidus secondary to metatarsus primus elevatus. The procedure permits repositioning of the first metatarsal in the sagittal plane and is particularly effective if the first metatarsal is long.

A common use that has evolved for the procedure has been in conjunction with a hypermobile first ray or in patients with ligamentous laxity. Hypermobility of the first ray has classically been noted as a precursor to hallux abducto valgus deformity (8). However, exactly what constitutes abnormal motion within the medial column has not been firmly established. First ray motion involves two distinct joints: the medial naviculocuneiform joint and the first metatarsocuneiform joint. The primary source of motion in a normal first ray is at the medial naviculocuneiform joint (9,10). Specifically, an average of 12.3 degrees of motion has been noted at the medial naviculocuneiform joint and 5 degrees at the first metatarsocuneiform joint (10). Gellman et al. found that the first metatarsal itself could dorsiflex about 5.0 degrees (11). Wanivenhaus and Pretterdklieber described the dorsal shift from neutral at the base of the first metatarsal as measuring about 2.6 mm (12). Furthermore, the actual shape of the first metatarsocuneiform joint has been proposed to have an influence on the range of motion as well (13,14). However, the contribution of each component joint to the total range of first ray motion and the amount of motion available as a whole will vary, in some instances to a significant degree (10,15).

Clinical studies have appeared to support the values derived from the laboratory and have demonstrated that patients with hallux abducto valgus deformity may possess a greater degree of first ray mobility compared with control patients (16). Additional studies have shown an association between a hypermobile first ray and generalized ligamentous laxity. An evaluation of 50 patients presenting with various foot problems revealed a marked increase in the intermetatarsal and hallux abductus angles when hypermobility was present (17). Hyperflexibility of the thumb has been associated with first ray hypermobility, yet no correlation was found between first ray motion and sex, age, intermetatarsal angle, size, skin stretch, hyperextension of the knee, or shape

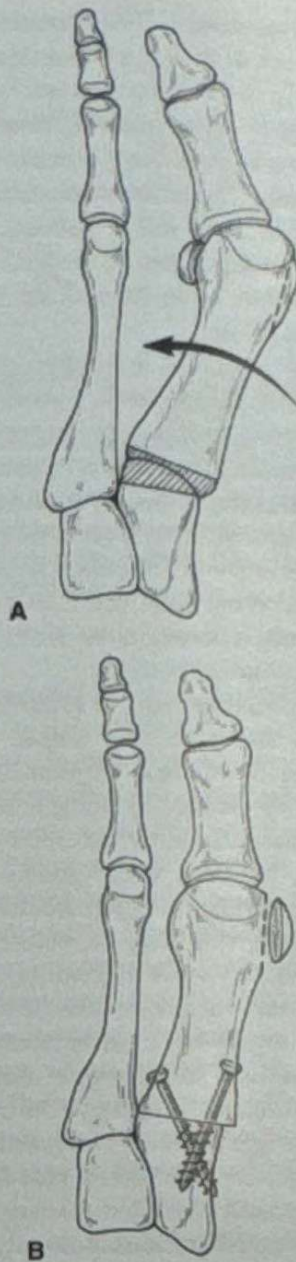


FIG. 20. A,B: The first metatarsocuneiform arthrodesis for correction of hallux abducto valgus deformity.

of the distal cuneiform (14). In female patients with symptomatic hallux abducto valgus, a statistically significant correlation was found with mild generalized hypermobility when compared with a similar control patient group (18).

Radiographic features associated with hypermobility are difficult to assess and are generally nonspecific. Most radiographic findings are secondary to structural changes that develop over time. A modified Coleman block test has been recommended to produce maximum dorsiflexion and plantarflexion of the first ray to assess motion at the first metatarsocuneiform joint with a lateral radiograph. Although this test may demonstrate the motion available at the joint, no objective studies have been conducted to demonstrate its reliability (19). Cortical thickening of the second and possi-

bly third metatarsals on an anteroposterior radiograph may provide indirect evidence of a hypermobile first ray.

Hallux abducto valgus deformity resulting from hypermobility of the first ray has been described as a prime indication for arthrodesis of the first metatarsocuneiform joint (5,20–25). This procedure can indirectly restore functional stability to the medial column by allowing the peroneus longus muscle to have a greater mechanical advantage at the medial naviculocuneiform joint, where the majority of first ray motion occurs. Furthermore, this procedure has also been recommended in patients with concomitant hallux abducto valgus deformity associated with a hypermobile flatfoot (24,25).

However, a hypermobile first ray is a relative, but not an absolute, indication for first metatarsocuneiform arthrodesis. Numerous procedures have proven successful in the repair of bunion deformities, many in patients who undoubtedly possessed a hypermobile first ray. Most first ray mobility occurs at the naviculocuneiform level (9). Although arthrodesis at the more distal joint may enhance stability, other methods such as a modified Young procedure or naviculocuneiform joint arthrodesis may also prove suitable. Furthermore, orthotic devices may be employed to address medial column instability postoperatively. The actual selection of the procedure is based on the knowledge, skill, training, and experience of the surgeon and on the specific clinical findings and concerns unique to the patient. Numerous options may be suitable for any given situation.

First metatarsocuneiform arthrodesis has also been recommended for adolescents with hallux abducto valgus deformity. Several studies in this patient population have demonstrated good results (21,24). Although this procedure has been recommended for adolescents with a closed epiphysis, the procedure may be used in adolescents with an open growth plate with no complications. Smooth wires or pins are used for fixation in this setting. Temporary use of smooth pins has not been found to damage an open growth plate (5,26). However, because growth plate damage may develop secondary to periosteal dissection (7), one must be careful to avoid unnecessary stripping of the soft tissues away from the physis. Myerson et al. found that in adolescents with a hypermobile first ray, realignment could be accomplished with a first metatarsocuneiform arthrodesis without distal soft tissue release or exostectomy (24). Avoiding surgery at the metatarsophalangeal joint may be an option in juvenile or adolescent patients who have no joint adaptation, but once lateral contracture has developed, then release of the joint appears prudent.

Salvage of previously failed hallux abducto valgus surgery with recurrent or residual metatarsus primus adductus is another indication for first metatarsocuneiform arthrodesis, especially if recurrence is secondary to hypermobility or ligamentous laxity. However, in many instances, the previous operation may have shortened the first metatarsal, so a bone graft may be necessary to prevent any additional shortening or to restore more functional length.

Arthrodesis of the first metatarsophalangeal joint has been recommended when the first metatarsocuneiform angle is medially deviated more than 30 degrees (26). However, variations in the angular relationships at this level have been found based on the position of the foot in addition to the orientation of the x-ray beam (17,27). Furthermore, ligamentous laxity was noted to have little to no effect on the metatarsocuneiform angles (17). This finding suggests that angular deviation should not be used as a sole criterion for tarsometatarsal arthrodesis. In some instances, a lateral weight-bearing radiograph may demonstrate sagittal plane subluxation with plantar gaping of the metatarsocuneiform joint.

Surgical Technique

The surgical incision is placed dorsally or medially over the first metatarsocuneiform joint. This may be a proximal extension from the incision used for exposure of the first metatarsophalangeal joint or a separate second incision. The medial dorsal cutaneous nerve is usually encountered in the subcutaneous tissue and should be retracted. Once the deep fascia is incised, the extensor hallucis longus is easily retracted to access the dorsal aspect of the joint. Medially, the tibialis anterior is freed from its distal fascial investments, so the tendon may be retracted dorsally to access the plantar aspect of the joint better and to facilitate fixation when a medial plate is used. The location of the joint may then be identified.

A linear incision is then made over the capsule and periosteum, which are carefully reflected. Caution is warranted during dissection of the lateral portion of the joint in an effort to avoid damage to the deep peroneal nerve and the first perforating branch of the dorsalis pedis artery. Plantarily, one needs to release the thick tarsometatarsal ligaments. Attachments of the posterior tibial and peroneus longus tendons, as well as Lisfranc's ligament, frequently hinder removal of the joint surfaces because of their extensive attachments in this location. Full joint mobilization facilitates later débridement of the cartilaginous surfaces. Dissection is generally extended distally to the junction of the proximal and middle third of the first metatarsal. Exposure of the thick cortical bone along this area is important when compression screw fixation is used. The thick cortical bone in this area is an excellent area for screw head contact to aid in compression across the arthrodesis site. Additionally, screw and wire placement becomes technically easier when one begins from a more distal site. When a dorsal or medial plate is used, then dissection needs to be extended to expose most of the metatarsal shaft distally and to identify the naviculocuneiform joint proximally. If more proximal dissection is done, care must be taken to avoid inadvertent damage to the saphenous nerve.

The joint may be resected using the technique preferred by the surgeon. When power saws are employed, the first metatarsal may be manually reduced to the desired position. Care should be taken to align the first metatarsal in both

sagittal and transverse planes. This alignment often places the osseous structures in such a position that any wedging will tend to occur by default, as opposed to any freehand wedge resection that may be required otherwise. Osseous resection should proceed with care to avoid penetration of the second metatarsal. This occurs most often when the lateral aspect of the joint is not well visualized. If difficulty is encountered during transposition of the first metatarsal, the lateral proximal condyle at the base of the first metatarsal may also require resection.

Hand instruments may also be used to resect the joint surfaces. An osteotome and mallet is generally employed to begin the process, with curettes useful in some instances. A power bur may be helpful in reducing any remaining portions of cartilage or subchondral bone. With this technique, the surgeon is better able to preserve the normal contours of the joint and to achieve a good fit, generally with less bone resection. Therefore, when hand instruments are used, the correction of deformity is based on the ability to realign the joint about its normal articular shape.

Transverse plane correction may be achieved using a combination of wedge resections and simple repositioning, which is readily facilitated once the joint has been freed of the surrounding soft tissue. By using a power saw, the technique of reciprocal planing may be employed to remove areas of incongruity gradually until a good fit is achieved. However, in patients with more significant deformity, intentional wedge resections will likely be required. A laterally based wedge is preferably resected from the medial cuneiform because the distal articular surface of this bone typically exhibits some degree of deviation from the long axis of the first ray. Therefore, one is simply using the normal alignment to best advantage in reducing the intermetatarsal angle. In addition, wedge resection of the medial cuneiform preserves a large cancellous portion of bone for apposition.

Sagittal plane alignment of the first ray may be influenced by displacement of the first metatarsal dorsally or plantarily. This maneuver requires less bone resection, is technically simple, and avoids any additional shortening (5,25). If the metatarsal is shifted plantarily, a small ledge of bone at the dorsal joint level may be present that will require remodeling once the fixation has been applied. However, wedge removal, either dorsally or plantarily based, is an effective means of achieving greater degrees of correction. In some patients, a combination of both elements may be employed to achieve the desired position (Figs. 21 through 23).

Once the preferred alignment is achieved, and before the joint surfaces are approximated, a small drill or Kirschner wire may be used to fenestrate the medial cuneiform and first metatarsal base in an effort to facilitate arthrodesis. The first metatarsal and medial cuneiform are then repositioned, and provisional fixation is applied.

Bone Grafting

Supplemental bone grafts may also be employed with arthrodesis of the first metatarsocuneiform joint in several situ-

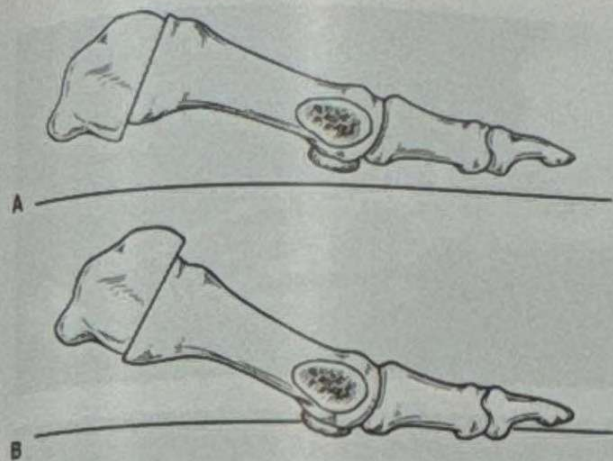


FIG. 21. During first metatarsocuneiform fusion, the sagittal plane position of the first metatarsal may be adjusted by shifting the metatarsal base dorsally (A) or plantarly (B) without resecting additional bone.

ations. This approach may prove helpful in patients in whom shortening of the first ray would not be tolerated, in patients requiring greater degrees of wedge resection for correction, or when significant changes in sagittal plane alignment are necessary. The graft source may include autogenous or allogeneous bone. However, some authors have recommended that allogeneic bone be avoided when rigid internal fixation cannot be obtained (28). When a nonunion or pseudarthrosis of a failed metatarsocuneiform joint arthrodesis is repaired, autogenous bone is preferred (29). Tricortical iliac crest graft is ideal for this procedure because the graft provides three cortical surfaces for excellent stability dorsally, plantarly, and medially. The cortical bone provides and maintains positional correction and allows the use of rigid internal compression across the arthrodesis site. The cancellous bone

provides a lattice network for osteoconduction throughout the healing process.

Modifications

Several authors have proposed several modifications to the basic technique described. The exostosis removed from the medial first metatarsal head has been used as a graft in the arthrodesis site to limit first metatarsal shortening (30). However, in most patients, the amount of bone resected is too small to have any meaningful effect on first metatarsal length. Other investigators have suggested that less aggressive resection of the joint may be adequate to provide suitable fusion. In some instances, cartilage has been removed to expose only the subchondral bone (22). When the joint is wedged for correction of the metatarsus primus adductus, several authors have resected bone from the lateral aspect of the joint, to leave the cartilage intact medially (22,24). Mauldin and associates released the joint, adjusted the position of the metatarsal, then applied the fixation. A medial trough was created in the medial first metatarsocuneiform joint, and an onlay graft was applied (23).

Fixation

Because of the relatively transverse orientation of the first metatarsocuneiform joint, numerous options are suitable for stabilizing the area. Kirschner wires or Steinmann pins provide good fixation and are quick and easy to use. Generally, two wires are preferred, to reduce any potential for rotation and to create additional stability. Pins may prove advantageous in patients with osteopenia and in pediatric patients with an open growth plate. Another advantage of using wires is that dissection may be more limited than when screws or plates are employed.

Compression screw fixation provides excellent stability and was first employed by Rutherford (20). Devices used to date most commonly consist of 3.5- or 4.0-mm fully or partially threaded cortical or cancellous screws inserted in lag fashion. These screws may be introduced in several orientations. Exposure along the proximal one-third of the metatarsal base is important, to ensure that the appropriate-length screw is used and that adequate compression is obtained by the screw head making contact with the thick cortical bone in this area. A common error is to begin screw placement too close to the arthrodesis site. The bone content here is more cancellous, and compression may be less effective. A key step with osteosynthesis in this area is adequate countersinking. This facilitates appropriate screw orientation into the plantar portion of the cuneiform, enhances optimal compression, prevents stress risers along the dorsal cortex of the metatarsal, and reduces the prominence of the screw head. Screws that cross the intercuneiform joints have not been noted to create any functional or symptomatic problem (22). Certainly, a combination of screws and wires may be used as well.

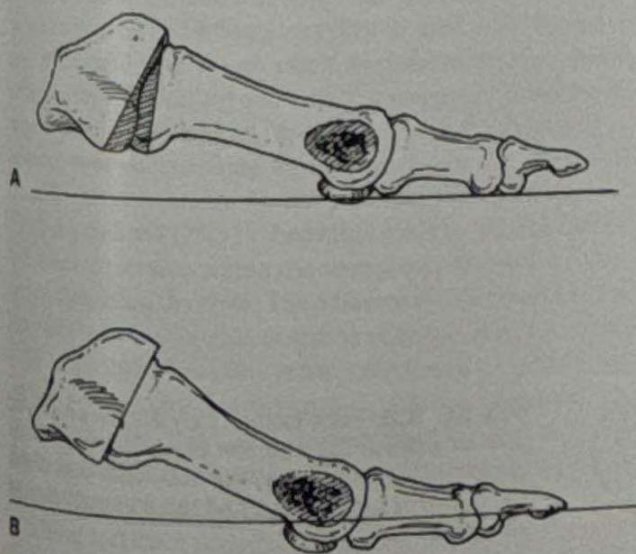


FIG. 22. A,B: A greater degree of plantarflexion of the first metatarsal may be achieved by resecting a plantar wedge from the joint area.

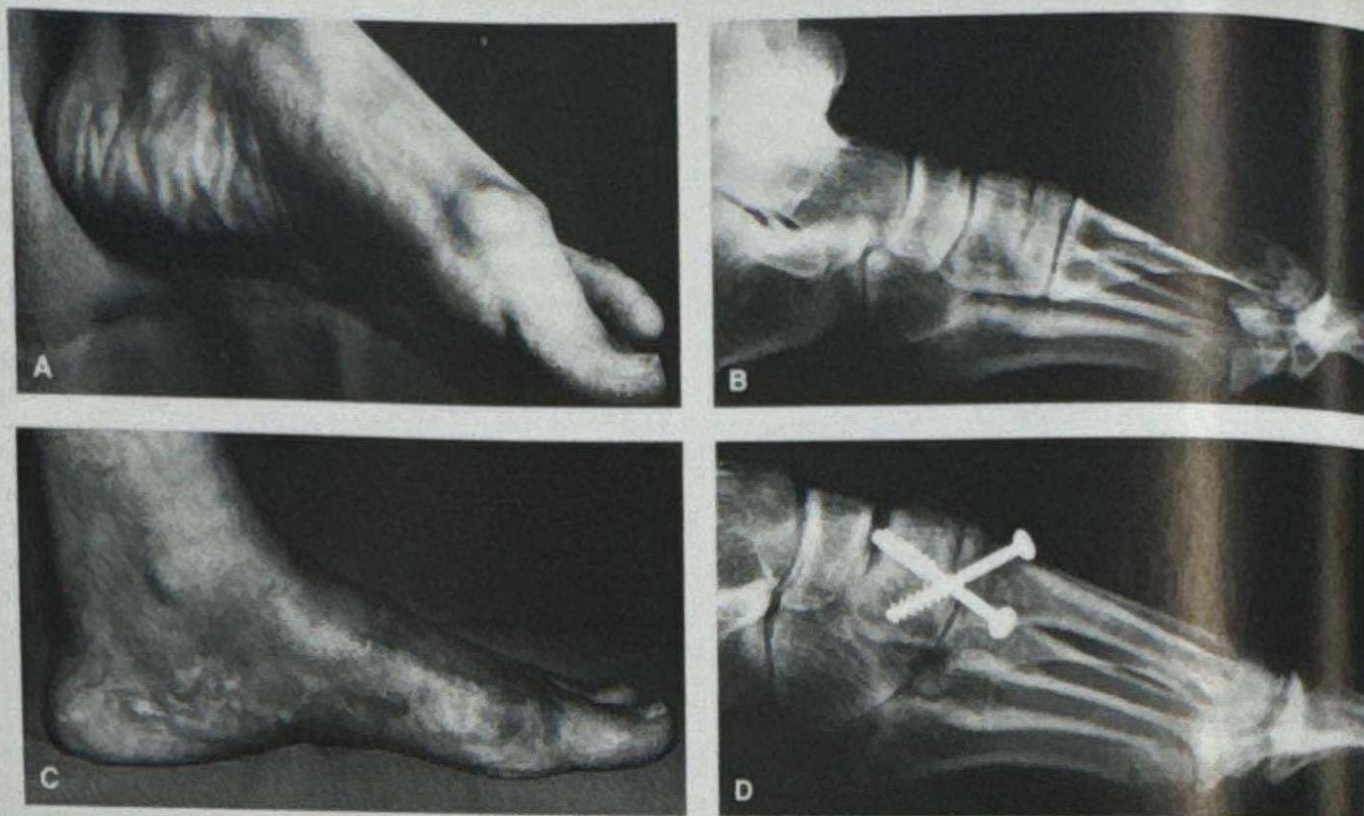


FIG. 23. Arthrodesis of the first metatarsocuneiform joint may also be used to alleviate metatarsus primus elevatus associated with a dorsal bunion. **A,B:** Preoperative clinical and radiographic appearance. **C,D:** Postoperative clinical and radiographic appearance.

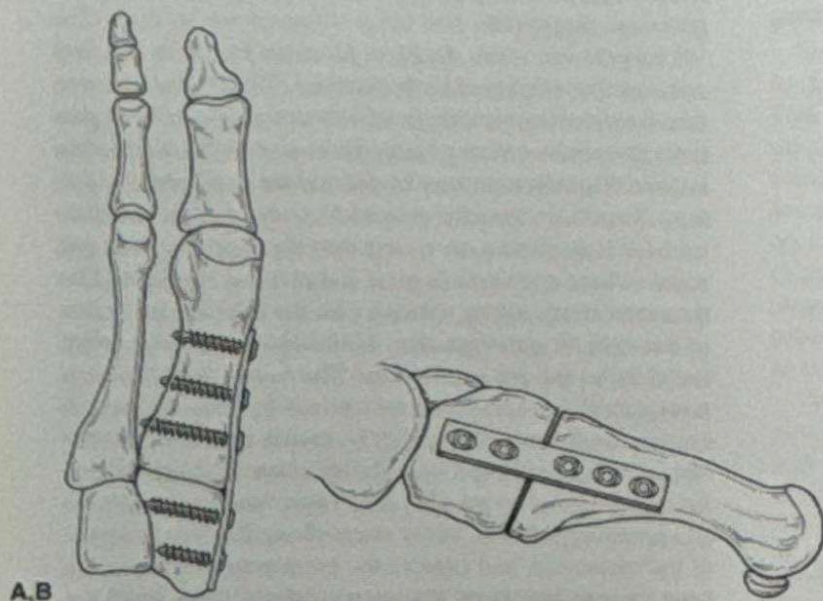


FIG. 24. **A,B:** Plate fixation may also be employed with or without the addition of an interfragmental screw. In many patients, the additional bulk of the plate proves problematic and requires subsequent removal.



FIG. 25. A medial plate works well when a large graft is incorporated into the arthrodesis site.

Cannulated screws have also proved useful for osteosynthesis. However, with some products, the screw head is large, and often this feature limits the ability to insert two screws in the area. The screws are placed in the same fashion as previously mentioned. The first step is to countersink. If desired, a rotary bur may be used for this purpose. Initial countersinking allows appropriate placement of the guide pin. The guide pin is then visualized through the metatarsal segment. At that point, the metatarsal is placed in the appropriate alignment, and the guide pin is then driven into the cuneiform segment.

Plate fixation is also an option for the modified Lapidus arthrodesis and is particularly useful when bone graft is used (Figs. 24 and 25). The technique may be employed in other situations when additional stability is preferred. However, the plate and screws are often prominent postoperatively after complete healing and create a source of irritation for many patients. Therefore, they often require subsequent removal, thus necessitating an additional surgery. Plate fixation has been described for the procedure in both dorsal and medial positions (25,31). Eccentric drilling can be used to afford compression across the arthrodesis site as the screws are inserted into the plate. The addition of a plantar interfragmentary screw was also noted to enhance stability further (31) (Fig. 26). However, when osteopenia is present and compression fixation is difficult to achieve, large-diameter Steinmann pins may be adequate. Burying the pins may prove helpful in eliminating pin tract irritation and loosening of the wires within the cast.

Chang and Ruch undertook a study to determine the effectiveness of different fixation methods for the first metatarsocuneiform fusion. A medial five-hole plate with a plantar screw was noted to resist disruptive forces to the greatest

degree. Other forms of fixation that were tested are listed in order of decreasing strength: crossed 4.0-mm screws, medial five-hole plate, and crossed Kirschner wires (31). However, this finding does not imply that any of these methods of fixation are inferior; it simply provides the surgeon with a means of assessing the available options. Each form of fixation has its own advantages and disadvantages, and any of these methods may be adequate for stabilizing the fusion site, provided patient compliance is good.

Postoperative Management

The patient is maintained non-weight bearing for 6 to 10 weeks or until radiographic evidence of an osseous union is noted. If bone grafting is performed, this non-weight-bearing period will be extended, typically for a minimum 12 weeks. Postoperative radiographs may be obtained at regular intervals to evaluate joint consolidation.

Ancillary procedures may be required for complete reduction of the hallux abducto valgus deformity. The release of deformity at the first metatarsophalangeal joint should be considered an integral part of surgical treatment. When the effective articular surface of the first metatarsal head is laterally deviated, a distal metaphyseal osteotomy may be necessary for cartilaginous realignment.

Results

Overall, the results obtained with first metatarsocuneiform fusion for the repair of hallux abducto valgus have been good (Fig. 27). Rutherford reported good results in more than 120 feet. Minor keratoses were said to develop beneath the second and third metatarsal heads in some patients, presumably from shortening of the first metatarsal. Otherwise, no specific problems were noted (20). Using the medial eminence of the first metatarsal head as a graft, Butson reported excellent or good results in 110 of 119 feet (92%) in patients evaluated between 2 and 16 years postoperatively. No cases of nonunion were reported. Fixation consisted of two Kirschner wires inserted between the shafts of the first and second metatarsals (30).

Clark and colleagues reported on 20 adolescent patients representing a total of 32 procedures. Good correction of deformity was noted, in addition to alleviation of the medial column hypermobility, which was noted in 93% of the feet preoperatively. Two patients sustained problems related to lesser metatarsalgia (21).

A thorough report was provided by Saffo et al., who evaluated patients undergoing 54 procedures between 1 and 5 years earlier. Of these patients, 82% reported good or excellent results. However, several problems were identified. Transfer lesions were found in 14% of the patients, although symptoms were experienced by only 4%. An asymptomatic pseudarthrosis was found in 12% of their patients. The first metatarsal was 6 mm shorter compared with the second metatarsal, but the authors believed that this was readily over-



FIG. 26. A,B: Preoperative clinical and radiographic appearance of a patient with hallux abducto valgus deformity, metatarsus adductus, and joint space narrowing at the medial first metatarsocuneiform joint. C,D: Immediate postoperative results. E: Radiographic appearance 10 weeks postoperatively. F: Clinical appearance 6 months postoperatively.



FIG. 27. A,B: Preoperative and postoperative radiographs 1 year after repair of hallux abducto valgus deformity with first metatarsocuneiform fusion.

come by the plantarflexion introduced in the medial column at the time of surgery (5).

A 10% nonunion rate was also present in the series of patients reviewed by Sangeorzan and Hansen, although all the patients with nonunion in their series were symptomatic. In patients in whom bone grafting was not used, an average shortening of 5 mm was reported. Overall, only 75% of patients achieved a successful result (22).

Using an inlay graft technique, Mauldin and colleagues found satisfactory or very satisfactory results in 90% of 51 feet in patients undergoing surgical procedures. However, trabecular bridging at the fusion site was noted in only 25% of the cases. Despite this finding, no correlation was found between the radiographic evidence of fusion and patient satisfaction. The intermetatarsal angle was reduced from an average preoperative value of 14.6 degrees to a postoperative value of only 8.7 degrees (23). This finding leads one to question whether better correction of the metatarsus primus adductus deformity could have been achieved with a more traditional joint resection.

Myerson et al. reported on 67 cases; 77% of their patients were judged to have achieved total resolution of their preoperative symptoms, and 15% achieved partial relief. Five dorsal bunions were noted at follow-up. Seven nonunions occurred, only one of which was symptomatic. Three neuromas of the deep peroneal nerve were noted (24). Moreover, patients were allowed to bear weight fully during the recovery

period. This could be one possible explanation for the demonstration of dorsal prominence of the metatarsal head.

Complications

Fortunately, major complications associated with the first metatarsocuneiform arthrodesis are not common. Because part of the motion of the first ray is eliminated, deviations in the sagittal plane may not be as well tolerated. Although some degree of plantarflexion of the metatarsal is desirable, excessive plantarflexion may result in sesamoiditis. Accommodative padding or orthoses may frequently resolve symptoms related to the plantar pressure. When conservative treatment fails, surgical treatment may include tibial or fibular sesamoid planning, tibial or fibular sesamoidectomy, or dorsiflexory wedge osteotomy of the first metatarsal in severe cases. A metatarsal resting in a more dorsal position could lead to additional pronation within the foot and is typically more difficult to accommodate.

Previous authors noted significant amounts of shortening of the first metatarsal in some instances (5,22). Excessive shortening of the first metatarsal has the potential to cause complications including transfer lesions, less effective hallux purchase, and metatarsalgia. Although one may compensate for shortening to some extent with plantarflexion of the first metatarsal, the amount of shortening that may be overcome is limited. Furthermore, significant plantarflexion

alters the loading of the plantar joint structures and encourages less effective purchase of the hallux, a problem that is compounded by shortening of the metatarsal. Such difficulties are more likely to occur in patients who require significant wedge resections to achieve the desired correction. The use of a bone graft may reduce the risks of this type of complication, but it also adds another level of complexity to the procedure and a more prolonged recovery process.

Neuritic symptoms have also been described in some patients (21,24). The medial dorsal cutaneous nerve will almost certainly be encountered during the dissection process, and if more proximal dissection is done, the saphenous nerve will often be visualized. The deep peroneal nerve may also be susceptible to disruption in the first interspace area. Proper tissue handling minimizes the risk of nerve entrapment. However, the normal scarring process that is part of healing may create nerve entrapment even in the best circumstances.

Hallux limitus is not a common complication, but it may be encountered as a consequence of any first metatarsophalangeal joint repair. Hallux limitus is more likely when the first metatarsal is lengthened with a graft as part of the fusion or when the arthrodesis heals with the first metatarsal in an elevated position.

Failure to achieve radiographic union of the arthrodesis site has been seen in about 10% of cases in several studies (5,22,24). Although this complication has generally been noted to be asymptomatic, painful nonunions have developed that have required subsequent surgical treatment (22) (Fig. 28).

Arthrodesis of the first metatarsocuneiform joint is a versatile procedure that may be employed in a variety of situations. Overall results have been suitable. Numerous forms of fixation are applicable and work well. Patients are best maintained non-weight bearing until healing of the osteotomy is achieved.



FIG. 28. A,B: Preoperative and immediate postoperative radiographs of a patient with recurrent hallux abducto valgus deformity with an associated hypermobile first ray. C,D: Radiographic appearance 3 months postoperatively demonstrating a delayed union that is asymptomatic. (continued)

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A,B: Preoperative and immediate postoperative radio-
 graphs of a patient with recurrent hallux abducto valgus deform-
 ity and an associated hypermobile first ray. C,D: Radiographic
 union 3 months postoperatively demonstrating a delayed
 union that is asymptomatic. (continued)



FIG. 28. Continued. E,F: Despite continued immobilization and an external bone stimulator, the patient
 developed an asymptomatic nonunion at the first metatarsocuneiform fusion site. This has been noted
 in several studies.

CUNEIFORM OSTEOTOMIES

Several authors have discussed cuneiform osteotomies for
 the correction of certain foot deformities. Cotton recom-
 mended an opening wedge osteotomy of the medial cunei-
 form with allogeneic femoral graft to correct sagittal plane
 deformity in collapsed pes valgus (32). Other investigators
 have used an opening wedge cuneiform osteotomy for cor-
 rection of residual forefoot adductus in the treatment of club-
 foot deformity (33,34). Joplin performed an opening wedge
 osteotomy for repair of splay foot deformity associated with
 hallux abducto valgus (35) (Fig. 29). Graver recommended
 a similar procedure for the correction of metatarsus primus
 abductus and used a triangular piece of bone from the re-
 sected medial eminence of the first metatarsal (36). Hara
 and associates employed a completely different approach,
 by resecting a closing abductory wedge from the medial
 cuneiform to reduce intermetatarsal splay for hallux abducto
 valgus (37) (Fig. 30).

Indications

Perhaps the primary indication for an opening cuneiform
 osteotomy is in conjunction with a repair of metatarsus ad-
 ductus with and without hallux abducto valgus. In this case,
 the opening wedge cuneiform osteotomy is generally com-
 bined with a closing wedge osteotomy of the cuboid. The

wedge of bone removed from the cuboid may then be used
 to augment the material inserted into the medial cuneiform
 (38). Other investigators have noted that cuneiform osteoto-
 mies may be employed in patients with hallux abducto val-
 gus who have increased obliquity of the first metatarsocu-
 neiform joint (37,39). However, questions have been raised

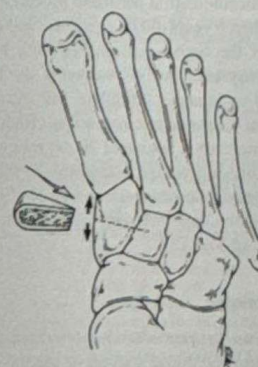


FIG. 29. The opening cuneiform osteotomy with graft for re-
 duction of the intermetatarsal angle associated with hallux
 abducto valgus deformity.

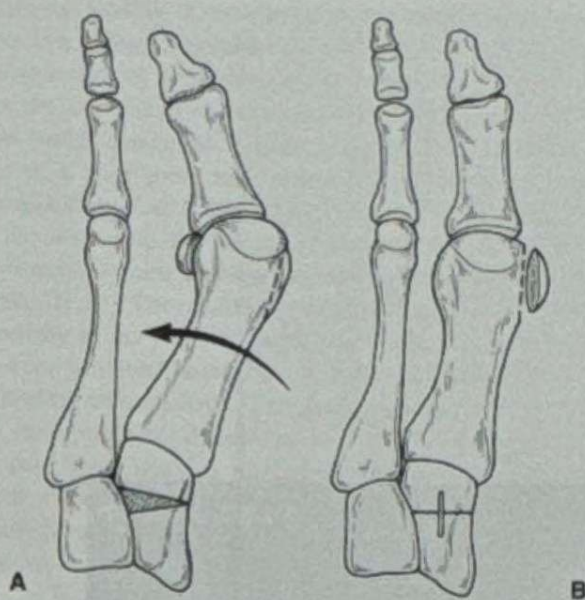


FIG. 30. A,B: The closing cuneiform osteotomy for repair of intermetatarsal splay associated with hallux abducto valgus deformity.

regarding the reliability of this measurement on standard radiographs (17,27).

Bacardi and Frankel employed a biplane opening cuneiform osteotomy for surgical repair of juvenile hallux abducto valgus (40). Lynch noted that juvenile hallux valgus was often associated with metatarsus adductus deformity, so this procedure is a logical choice in these patients or in patients with forefoot adductus. In addition to making an oblique osteotomy, wedging of the graft may be helpful in plantarflexing the medial column to address sagittal plane deformity or hypermobility (39). Ganley and Ganley noted that the procedure would be useful in correcting metatarsus primus adductus in patients after a failed closed base wedge osteotomy with residual dorsiflexion (38).

A general contraindication for these procedures has been in patients less than 6 years old because they have inadequate consolidation of the osseous structures (39). Furthermore, the procedure may need to be avoided if the bases of the first and second metatarsals articulate with each other (38). Graver noted that the procedure was not as effective in reducing larger intermetatarsal angles of 20 degrees or more (36). Relative to the closing wedge osteotomy of the cuneiform, Hara et al. reported that general contraindications were osteoporosis, bone blockage between the first and second metatarsals, or a rigid foot (37).

Surgical Technique

The opening wedge procedure is performed through a linear incision along the dorsal medial or medial aspect of the midfoot. The primary anatomic structures encountered are the extensor hallucis longus and tibialis anterior tendons and the medial dorsal cutaneous and saphenous nerves. The fas-

cia surrounding the tibialis anterior will need to be released to mobilize the tendon and obtain better access to the cuneiform. A linear periosteal incision is performed in the same orientation as the skin incision, and the tissue is freed. A power saw is used to create an osteotomy approximately 7 to 10 mm proximal to the metatarsocuneiform joint. The lateral cortex is initially maintained intact, but in most cases it fractures as the osteotomy is opened. A lamina spreader may be placed in the osteotomy to separate the two segments and to better determine the appropriate amount of bone graft that is necessary. Intraoperative radiographs may be obtained before insertion of the graft to assess reduction in the intermetatarsal angle.

Tricortical iliac crest allogenic bone graft is well suited for this procedure. Autogenous graft from the calcaneus has also been used with success (39). Fixation is not always necessary, but when it is employed, staples, pins, and wires are all appropriate. Postoperative management includes a 6- to 10-week period of non-weight bearing or longer until radiographs demonstrate consolidation at the host-graft interface.

Results

Graver reported having performed 23 cases of opening wedge cuneiform osteotomy with the medial eminence of the first metatarsal head as the donor graft. No specifics were provided for the group as a whole. Advantages of the procedure were said to be the ease of execution, rapid healing, and the lack of need for no internal fixation. He noted that the procedure could be used in patients with intermetatarsal angles of up to 20 degrees and that the first metatarsal should not be long (36).

Lynch provided the most comprehensive review on the use of the opening wedge osteotomy for the repair of hallux abducto valgus deformity. He described good results in 48 feet of adolescent patients. In addition, he noted that the procedure also provided stabilization of the medial column. Calcaneal allograft was employed, and staple fixation was applied. Capital osteotomies were often required to reduce a deviated proximal articular set angle (39) (Fig. 31).

Hara et al. recommended a different approach consisting of a first cuneiform closing wedge abductory osteotomy for reduction of metatarsus primus adductus in patients with intermetatarsal angles greater than 15 degrees and with pronounced obliquity of the first metatarsocuneiform joint. The procedure was said to be ideal in patients with space at the first intercuneiform joint and the opposing bases of the first and second metatarsals. Steinmann pins were used for fixation, and the patient was maintained non-weight bearing for 6 weeks. In 51 cases, no patients had delayed union or nonunion of the osteotomy. Arthrosis involving the intercuneiform joints did not develop (37).

Complications may include nonunion, graft displacement, and malunion if the graft is not fashioned appropriately. The ability to control precise levels of correction is not as certain



FIG. 31. Preoperative and postoperative radiographs of a patient after opening wedge cuneiform osteotomy with graft for repair of hallux abducto valgus deformity. (From Lynch FR. Applications of the opening wedge cuneiform osteotomy in the surgical repair of juvenile hallux abducto valgus. *J Foot Ankle Surg* 1995;34:103-123, with permission.)

as with other procedures, and in some cases inadequate correction has been noted.

Osteotomies of the cuneiform for the repair of hallux abducto valgus deformity are not commonly employed by most surgeons, but they may have merit. The proposed advantages of this approach include avoiding the growth plate at the base of the first metatarsal in the pediatric patient, the long radius arm that theoretically requires less wedging to gain correction when compared with distal osteotomies, and the ability to provide biplane correction. However, for most patients, other techniques have been better accepted and have proven successful, so determining specific indications for this approach remains difficult.

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