Proximal Osteotomy

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FIRST METATARSAL PROXIMAL
OSTEOTOMIES

Many components in various severities come together to form the hallux abducto valgus/metatarsus primus adductus condition commonly known to our patients as a "bunion." In this chapter, we are concerned with what could be called, in layman's terms, a "severe bunion," necessitating osteotomy at the base of the first metatarsal (Fig. 17-1).

There are numerous procedures and even more numerous variations for the correction of a severe metatarsus primus adductus. Those most commonly used today, which we cover in some depth, include the closing base wedge osteotomy, the opening base wedge osteotomy, the crescentic osteotomy, and the Logroscino double osteotomy. We also present some procedures that are less often used and historically interesting.

Our chief concern is presenting broad preoperative, postoperative, and fixation principles applicable to all the base osteotomies. Particulars are covered under specific sections.

Criteria

Hallux abducto valgus surgical criteria have been identified and recognized by many authors for years. We believe that strict adherence to preoperative criteria helps ensure a satisfactory surgical outcome. Templates can be very useful in determining the size of a wedge or position of an osteotomy, but should be used together with preoperative measurements.¹ A major problem in any osteotomy is shortening of the bone. We believe that any and all osteotomies shorten bone to some degree.

The purpose of this chapter is to describe the surgical correction of a specific first metatarsal deformity. It is imperative that consideration can be given to the biomechanical evaluation of the hallux valgus foot. Inman and other authors have identified excessive pronation of the foot as contributing to the formation of hallux valgus.²⁻³ Hypermobility of the first ray has been implicated in the formation of significant hallux valgus deformity. Proper biomechanical evaluation allows the surgeon to functionally accommodate the post-surgical foot with better long-term results.

When considering base wedge osteotomy procedures, the intermetatarsal (IM) angle determination is vital. Hardy and Clapham determined the intermetatarsal measurement in a 1951 study.⁴ The intermetatarsal angle is the most significant measurement used in deciding to perform an osteotomy at the base of the first metatarsal.

The Logroscino and Golden procedures correct a high IM angle and an abnormal proximal articular set angle (PASA). However, if the IM angle is easily corrected by a head or midshaft osteotomy, then biplane angling of the osteotomy will help to change the proximal articular set angle as well, thus eliminating the need for the double osteotomy. We believe therefore that proper IM angle determination is crucial.

The intermetatarsal angle is the relationship between lines bisecting the first and second metatarsal
Fig. 17-1. (A) Clinical appearance of a severe hallux abducto valgus deformity. Note the position of the hallux in relationship to the second toe. (B) Anteroposterior radiograph demonstrating severe hallux abducto valgus with high intermetatarsal angle and displacement of the sesamoid apparatus.

The normal IM is a source of controversy; however, it can be safely said that in a rectus foot as much as 10° is normal, and in an adductus foot, to 8° is normal. We believe that a base osteotomy should be considered in patients who have an intermetatarsal angle of 15° in a rectus foot or more than 12° in an adductus foot. It has been our experience that a head or shaft osteotomy can sufficiently correct an IM angle up to 15° (Fig. 17-2C to E). As always, clinical correlation is important. Visual examination of the foot may at times change the surgeon's mind about a head versus a base osteotomy. If the intermetatarsal angle exceeds 22°, we suggest the use of the first metatarsal medial cuneiform joint fusion or Lapidus procedure (Fig. 17-3).

The second important measurement criteria is the proximal articular set angle (PASA). The PASA is an angle determined by drawing a line transversely through the effective articular cartilage of the first metatarsal head, then dropping a line perpendicular to that. This perpendicular is then compared to the bisection of the first metatarsal shaft (Fig. 17-4). A normal PASA is considered to be 8° or less. Gudas and Marcinko describe an "effective proximal articular set angle," which they state is usually greater than the radiographic measurement. This effective PASA is de-
Fig. 17-2. (A) Intermetatarsal (IM) angle measurement in a rectus foot. (B) IM angle measurement in an adductus foot. (C) Radiograph demonstrating failed head osteotomy bilaterally. An attempt was made to correct a significantly large IM angle by means of a head osteotomy. Consideration should have been given to a base osteotomy as the IM angle was higher than 15°. *(Figure continues.)*
Fig. 17-2 (Continued). (D) IM angle of 15° or less responding well to a head osteotomy. (E) IM angle greater than 15°, necessitating base osteotomy.
Fig. 17-3. (A) Diagram of Lapidus procedure demonstrating the bone to be resected, including the hypertrophied medial eminence and cartilaginous surfaces of the base of the first metatarsal and corresponding distal aspect of the medial cuneiform. (B) Completed Lapidus procedure.
The radiographic position of the first metatarsal phalangeal joint should be considered. A congruous joint demonstrates no angulation within the joint. Lines representing the effective articular cartilaginous surfaces of the base of the proximal phalanx and the head of the first metatarsal are parallel (Fig. 17-5A). In a deviated joint, the lines representing the effective articular cartilage of the joint appear to be intersecting outside the joint (Fig. 17-5B); a subluxed joint shows these lines intersecting within the joint (Fig. 17-5C). Evaluation of congruity of the joint and range of motion are necessary for determining the viability of joint preservation versus joint destructive procedures. Base osteotomies may be performed with either a joint destructive or a joint preservative procedure at the metatarsal head.

The relative metatarsal protrusion is measured on the radiograph preoperatively. A normal protrusion measurement demonstrates the second metatarsal as being longer than the first metatarsal, although a range of plus or minus 2 mm is considered within normal limits (Figs. 17-6 and 17-7). If the first metatarsal is found to be equal in length to the second metatarsal or longer, then a closing base wedge osteotomy can be performed, as a slight shortening of the first metatarsal will take place. This procedure was first described by Loison and Balasescu.

Another method for determining relative metatarsal length is by measuring the metatarsal parabola angle. With the apex at the distal aspect of the second metatarsal, a line is drawn to the distal aspects of the first and fifth metatarsal heads respectively. An angle is formed, the average of which is found to be 142.5° (Fig. 17-8). The normal metatarsal length relationship in order of decreasing length is 2:1:3:4:5.

As in any surgery, the patient’s overall physical and emotional condition must be taken into account preoperatively. Of course, circulatory status must be adequate to ensure healing. Bone stock quality is also extremely important. In the case of any base osteotomy where internal fixation is absolutely essential, bone quality becomes crucial. Osteoporotic or cystic bone should be avoided at all costs when considering a base osteotomy.
Fig. 17-5. Diagram demonstrating joint position. (A) Parallel lines demonstrating effective articular cartilage in a congruous joint. (B) Intersection of the lines outside the joint show a deviated joint. (C) Lines intersecting within the joint demonstrating a subluxed position.
**Fig. 17-6.** Relative metatarsal protrusion. A normal is ±2 mm relative to the first and second metatarsal heads.

**Fig. 17-7.** Anteroposterior radiograph demonstrating normal metatarsal protrusion.

**Fig. 17-8.** Metatarsal parabola angle. Note the normal angle of 142.5°.
Preoperative Planning

Sharpe,\(^9\) in determining the size of the wedge of bone to be resected for a closing base wedge osteotomy, presented a mathematical formula (Fig. 17-10). Gerbert\(^1\) talks about the use of templates to determine wedge size as is shown in the illustration (Figs. 17-11A to D). It has been suggested that determining the amount of correction desired will aid in choosing the size of the wedge necessary. For example, if an intermetatarsal angle of 18° is noted preoperatively and an angle of 8° is desired postoperatively, then a 10° wedge should be made in the bone.

Others believe that the osteotomy should be made in the traditional fashion, with one cut perpendicular to the shaft of the first metatarsal, and the second cut parallel to the desired articular surface of the head (Fig. 17-12). Another theory involves the "hinge axis concept,"\(^13\) which stresses the importance of keeping the cuts perpendicular to the weight-bearing surface, rather than perpendicular to the surface of the bone (Fig. 17-13). It is believed that dorsiflexion of the capital fragment can be prevented by keeping the cuts perpendicular to the weight-bearing surface. Each method of determination of osteotomy size is presented here.

Surgical Approach

The surgical approach for the first metatarsal base osteotomy consists of a dorsolateral skin incision approximately 10 to 12 cm long (Fig. 17-14). The incision begins distally at the interphalangeal joint dorsal crease, medial to the extensor hallucis longus (EHL) tendon, and courses proximally until it eventually ends at the metatarsal cuneiform articulation. An 18-gauge needle can be used to demonstrate the location of the metatarsal cuneiform joint and to aid in making the incision (Fig. 17-15). The subcutaneous tissues at the base of the first metatarsal are divided just medial to the extensor hallucis longus tendon. Sharp dissection removes the capsule and periosteal tissues. With careful dissection over the hinge area of the proposed wedge, the capsule and periosteal tissues can be left intact to help strengthen the hinge.\(^13\) Important neurovascular structures to be aware of in this area are the dorsal vein that traverses the base of the first metatarsal, the deep plantar artery between the base of the

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**Fig. 17-10.** Demonstration of Sharpe's technique for determining the size of the wedge of bone to be resected for a closing base wedge osteotomy. (1) The IM angle is drawn. The portion along the first metatarsal shaft is labeled A-B. (2) A line is drawn where the osteotomy is planned. This line is labeled D-E. (3) A line is drawn showing the eventual position of the first metatarsal. This line is labeled A-C. (4) Line D-E is measured. This line is then projected from point A along line A-B to point F, and then from point A along line A-C to point G. (5) Joining points F and G determines the width of the base wedge necessary to obtain the desired correction. (6) If an opening base wedge is to be performed, the width of the graft equals the distance between points F and G.
Fig. 17-11. (A-D) Radiographs demonstrating template cutout technique for determining osteotomy size.
Fig. 17-12. Traditional orientation of osteotomy cuts for closing base wedge.

Fig. 17-13. Hinge axis concept. (A) The osteotomy is made perpendicular to the shaft of the first metatarsal, which causes a metatarsus primus elevatus postoperatively. (B) The osteotomy cut is demonstrated perpendicular to the supporting surface, which helps to prevent metatarsal dorsiflexion postoperatively.
first and second metatarsals, and the medial dorsal cutaneous nerve which crosses within the base of the first metatarsal (Figs. 17-16 to 17-24).

At the level of approximately 1 to 1.5 cm distal to the metatarsal cuneiform joint, the chosen osteotomy is performed. The decision to perform a closing, opening, or crescentic base osteotomy is made by carefully evaluating the relative metatarsal protrusion. On completion of the osteotomy, the surgeon's choice of fixation is utilized and the area is closed in the normal fashion. Cast immobilization of 6 to 8 weeks is necessary, with 4 to 6 weeks being non-weight-bearing. Bony healing will be evidenced on serial x-ray evaluation postoperatively.
Fig. 17-16. Diagram demonstrating the superficial and deep structures encountered with the dorsolinear incision over the first metatarsal. Note in particular the dorsal vein traversing the base of the first metatarsal, which many surgeons believe to be a good landmark for placement of base osteotomy.
Fig. 17-17. Superficial venous network surrounding the first MTPJ.

Fig. 17-18. Identification of the proper tissue plane between the superficial fascia and the capsule of the first MTPJ by means of blunt dissection. This pocket is found both distally and proximally at the base of the first MTPJ. The joining of these two pockets allows for easy layer dissection.

Fig. 17-19. Entering the lateral aspect of the first MTPJ. Note the extensor hallucis longus tendon.

Fig. 17-20. Sharp tenotomy of the extensor hallucis brevis tendon (arrow). Note the position and presence of the extensor hallucis capsularis (arrowhead).
Fig. 17-21. The conjoined adductor tendon in the first interspace, prior to tenotomy.

Fig. 17-22. Sharp lateral capsulotomy

Fig. 17-23. The periosteum and capsular tissues being incised by sharp dissection over the base of the first metatarsal.

Fig. 17-24. Periosteal stripping via Freer elevator in preparation for base osteotomy.
CLOSING ABDUCTORY BASE
WEDGE OSTEOTOMY

History
The most commonly used base osteotomy is a traditional closing base wedge, first described by Loison in 1901 and performed by Balacescu in 1903. The Loison and Balacescu osteotomy was first described as a linear osteotomy at the base of the first metatarsal.

Surgical Procedure
This osteotomy can be described as a closing abductory base wedge with the apex facing medially and the base directed laterally (Fig. 17-25). Ruch and Banks find it helpful to drive a Kirschner wire (K-wire) perpendicular to the metatarsal shaft where the apex of the wedge should fall (Fig. 17-26). This serves as a guide to ensure preservation of the medial hinge. As pressure is applied to the medial aspect of the first metatarsal head in an attempt to close the intermetatarsal angle, the hinge is "feathered" using the power saw until closure of the osteotomy site is achieved. This is also referred to as reciprocal planing by Patton and Zelichowski. The intermetatarsal angle is corrected, and correction is maintained by rigid internal fixation. The capsule and peristeal tissues are closed over the osteotomy using layer closure (Figure 17-27).

Fig. 17-25. (A) Diagram demonstrating a closing base wedge abductory osteotomy with section of bone to be removed. (B) Completed closing base wedge osteotomy.
OBlique ABDUCTORY BASE WEDGE OSTEOTOMY (JUVARA)

History

In 1919, Juvara first performed an oblique base wedge osteotomy from proximal medial to distal lateral, angled at approximately 40° to the long axis of the first metatarsal shaft. Originally, the shape of the resected bone was trapezoidal with the medial and lateral cortices transected and the lateral base wider than the medial. Juvara also described a reversed version of his osteotomy in which the wedge ran from proximal lateral to distal medial with a wider base laterally. In the 1970s, the Juvara, which had fallen out of favor because of instability, was revived with the introduction of Arbeitsgemeinschaft fur Osteosynthesefragen/American Society of Internal Fixation techniques and the modification of the cut to a true wedge with an intact medial hinge.

Surgical Procedure

The base wedge should be planned with its medial hinge 1 to 1.5 cm distal to the metatarsal cuneiform articulation. The distal cut is performed at an angle to the long axis of the metatarsal determined by the intermetatarsal correction needed. It must be kept in mind that the proximal cut will be made at approximately 40° to the long axis. The oblique design of the osteotomy not only allows for ease of fixation, but also provides a longer radius arm for rotation of the capital fragment around the hinge axis. This causes greater reduction of the intermetatarsal angle for each degree of rotation. It is suggested that the distal cut be made first so the proximal cut can be made in relatively stable bone, disrupting the hinge as little as possible (Figs. 17-28 to 17-32). The head of the metatarsal is
Fig. 17-28. (A) The Juvara base wedge abductory osteotomy with demonstration of bone to be resected. (B) The completed Juvara osteotomy.

Fig. 17-29. Base of the first metatarsal stripped of its periosteal tissue in preparation for osteotomy. Note identification of the first metatarsocuneiform articulation by means of an 18-gauge needle.
Fig. 17-30. The hinge axis guide is in place. The Juvara osteotomy completed, demonstrating the section of bone to be removed (arrow).

Fig. 17-31. The completed Juvara osteotomy before reciprocal planing and feathering of the medial aspect for proper closure.
Fig. 17-32. The completed Juvara osteotomy with good approximation of the ostotomy site.

Fig. 17-33. Maintenance of closure of the IM angle before internal fixation by means of bone clamp.
moved laterally, and the intermetatarsal angle is closed. A bone clamp is then used to stabilize the osteotomy site while it is fixated (Fig. 17-33). The choice of fixation technique is left to the surgeon; however, we strongly recommend screw fixation. As a rule, one screw is used, but a rule of thumb is that "two screws are better than one." So long as the osteotomy is long enough to allow for the use of two screws without jeopardizing cortical strength, it is preferable to use two screws instead of one. In the case of one screw, if the fixation is lost or fracture of the medial hinge should occur, then rotation and dorsiflexion of the capital fragment may be the result. If, however, the surgeon is not proficient in AO/ASIF techniques, crossed K-wires are an alternate form of fixation (Fig. 17-34).

CRESCENTIC/ARCUATE BASE OSTEOTOMY

History

The development of the arcuate or crescentic saw blade lead to the development of the crescentic base osteotomy. The advantages of this osteotomy include the fact that no wedge of bone is removed; thus, it is suitable for use in short first metatarsals (i.e., those in which the first metatarsal is more than 2 mm shorter than the second metatarsal). The proximal and curved nature of the osteotomy cut helps ensure maximum correction of the intermetatarsal angle with a minimal displacement of the osteotomy (Fig. 17-35). The main drawback of this procedure has been its inherent instability and difficulty in achieving sufficient fixation; thus, it has not been widely used.

Surgical Procedure

Mercado\textsuperscript{17} and Patton and Zelichowski\textsuperscript{14} all recommended making a longitudinal score in the metatarsal shaft at the level of the proposed osteotomy. This is referred to as a "register mark," and shows subsequent displacement of the metatarsal shaft (Fig. 17-36). The size of the crescentic blade is chosen according to the width of the first metatarsal shaft. This is essential, because these blades must be kept perpendicular to the shaft and cannot be torqued or they will break. The osteotomy is made so the apex of the arc faces proximally. Mercado\textsuperscript{17} suggested that care must be taken so that the plantar cortex remains intact, whereas most other authors recommend transecting the plantar cortex completely.\textsuperscript{14} Lateral pressure is then applied to the medial aspect of the first metatarsal head, closing the IM angle. The register mark should only move a couple of millimeters to prevent overcorrection of the IM angle.

Fixation of crescentic osteotomies is notoriously difficult. Keeping the plantar cortex intact, although difficult, helps to stabilize the osteotomy, but excessive motion with resultant malunions or nonunions is common. We recommend crossed K-wires as the fixa-
Fig. 17-35. Placement of the crescentic base osteotomy. Note the register mark.

Fig. 17-36. Completion of the crescentic osteotomy with lateral displacement of head and medial displacement of register mark.
Fig. 17-37. The completed crescentic osteotomy stabilized by crossed K-wires.

Fig. 17-38. Radiograph demonstrating completed crescentic base osteotomy fixated by crossed K-wire technique.

tion method of choice, or the use of a single screw (Figs. 17-37 and 17-38).

OPENING BASE WEDGE OSTEOTOMY

History

The original opening base wedge osteotomy was described by Trethowan in 1923. The most common modification was that performed by Stamm in 1957. Trethowan’s technique is best described as an opening wedge on the tibial side of the first metatarsal base. The osteotomy is filled with a portion of bone removed from the hypertrophied medial eminence of the first metatarsal head. Stamm described a similar technique in which he used a graft from the base of the proximal phalanx of the hallux (as in the Keller procedure) to insert into the base osteotomy.

Surgical Procedure

When an opening base wedge is performed, the apex of the cut faces laterally and the base medially. A bone graft is used to hold open the space that is formed on closure of the IM angle (Fig. 17-39). Stable internal fixation is necessary to allow the graft to remain in place. Although this choice remains with the surgeon, we find that a bone staple is the most effective form of fixation (Fig. 17-40). The staple prongs purchase the
Fig. 17-39. (A) Opening abductor base wedge osteotomy. This diagram demonstrates proper placement of the osteotomy at 1-1.5 cm distal to the metatarsocuneiform articulation. Note that the bone removed from the hypertrophied medial eminence (Trethowan) or from removal of the base of the proximal phalanx (Stamm) may-be used as a bone graft. (B) Placement of the bone graft in the opening wedge osteotomy.
medial shaft on either side of the graft, with the body of the staple helping to further stabilize the graft (Fig. 17-41).

**DOUBLE FIRST METATARSAL OSTEOTOMY (LOGROSCINO)**

**History**

In 1948, in response to a rising number of new surgical procedures for the correction of the hallux valgus deformity, Logroscino recommended a double osteotomy of the first metatarsal. His initial article described two osteotomies, one at the base and one at the head of the first metatarsal. He used this procedure primarily for the correction of severe inclination of the first metatarsal. Logroscino combined the techniques that had previously been performed by Reverdin (1881), Loison and Balasescu (1902), and Trethowan (1923). The procedure consisted of a distal closing adductory osteotomy as described by Reverdin and a proximal metatarsal osteotomy performed with either a closing abductory wedge osteotomy as described by Loison and Balasescu, or an opening abductory wedge osteotomy as described by Trethowan.
Reverdin described this technique as a linear resection through the distal portion of the first metatarsal. This procedure is best summed up as removal of a medial closing adductory wedge from the head or the neck of the first metatarsal and resection of the medial eminence. Logroscino identified two types of osteotomies performed at the base of the first metatarsal, the closing abductory wedge osteotomy and the opening abductory wedge osteotomy. The choice of procedure is made by the surgeon on the basis of careful evaluation of the length of the first metatarsal and the metatarsal protrusion measurement. The closing or opening base wedge portions of the procedure were described previously in this chapter.

Joshua Gerbert advocated the use of the Logroscino technique when a bicorrectional Austin would not correct a very high IM angle, or in the case of an abnormally long or short first metatarsal, Kelikian states that he fails to see the advantage of the Logroscino procedure. In his opinion, it creates unnecessary problems in maintenance of position, and prolongs convalescence while increasing surgical trauma.

Fig. 17-42. Sharp dissection is made into the first MTPJ capsule. Care is taken to avoid the proper digital branch of the medial dorsal cutaneous nerve (arrow).

Fig. 17-43. Lenticular capsulotomy of first MTPJ with exposure of the hypertrophied medial eminence.
1971, however, Weil and Smith reported excellent results with the Logroscino procedure.

**Surgical Procedure**

The incisional approach to the Logroscino double osteotomy is identical to that for other base osteotomies, as discussed earlier. With the Logroscino, however, dissection must be carried out at the level of the first metatarsal phalangeal joint (MTPJ) as well, to accommodate the distal osteotomy.

The subcutaneous tissues at the level of the MTPJ are divided by sharp and blunt means. The scalpel can be used for both sharp and blunt dissection. Blunt dissection is performed by turning the cutting edge of the blade on an angle toward the capsular tissue. This allows the surgeon to push away the soft tissue with the back end of the scalpel with only a partial exposure of the capsule and soft tissue interface to the cutting edge of the blade. As always, care is taken to avoid neurovascular structures, especially the proper digital branch of the common peroneal nerve (Fig. 17-42). The capsule is entered and reflected from the first metatarsal head dorsally, medially, and plantarly. The choice of capsulotomy (i.e., L-shaped, lenticular, Washington Monument, etc.) rests with the surgeon (Fig. 17-43).

Extensor hallucis brevis tenotomy and lateral capsulotomy are performed in the first interspace (see Figs. 17-16 to 17-24). We do not recommend fibular sesamoidectomy, because a base wedge osteotomy is being performed and the risk of a hallux varus increases with overzealous closure of the IM angle. The medial eminence is resected parallel to the sagittal groove, leaving a slightly wider plantar medial shelf (Fig. 17-44).

We recommend that the base wedge osteotomy be performed first. We strongly believe that closure of the IM angle effectively increases the PASA measurement. Care must of course be taken to ensure that the base osteotomy remains stable while the distal first metatarsal cuts are made. Attention is then redirected to the head of the first metatarsal, where a Reverdin-type procedure, a closing adductory wedge osteotomy, is performed. The apex of this osteotomy faces laterally and the base medially. There are several famous modifications of the original Reverdin, including but not limited to Green's distal L procedure, Laird's, and Todd's; however, in conjunction with the base osteotomy, the simple Reverdin procedure will suffice. On completion of the Reverdin, fixation is once again utilized to maintain the osteotomy position. An opening or closing base wedge osteotomy is then performed to complete the double osteotomy procedure (Fig. 17-45).

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*Fig. 17-44. Power removal of the hypertrophied medial eminence in line with the sagittal groove.*
Fig. 17-45. (A) Diagram demonstrating bone to be resected for the Logroscino procedure. Note correction of the high IM angle as well as abnormal proximal articular set angle. (B) The completed Logroscino procedure. (C) Radiograph demonstrating the Logroscino double osteotomy.

GOLDEN BASE OSTEOTOMY WITH DISTAL SOFT TISSUE RELEASE

History

The Golden osteotomy was designed in 1961 to be used when there was a high IM angle but the PASA did not warrant the marked correction produced by the Logroscino. This procedure is not commonly used in its original form, because of the technical difficulty in making the osteotomy cuts and the inherent instability.16

Surgical Procedure

Golden originally described his base wedge as similar to Roux's, Peabody's, or Mitchell's16; that is, a trapezoidal abductory wedge, the base of which faced laterally, the apex medially. A lateral ledge of bone was preserved to provide additional stability. Both the medial and lateral cortices were transected, thus causing stability problems (Fig. 17-46). Distally, Golden performed a resection of the hypertrophied medial eminence and the release of the adductor hallucis tendon laterally. As was discussed earlier, this procedure is
not very popular because the proximal osteotomy is not stable.

**LUDLOFF AND MAU**

**History**

In 1918 Ludloff proposed an oblique osteotomy of the first metatarsal shaft from dorsal proximal to plantar distal for the correction of metatarsus primus varus. This procedure was revised by Mau in 1926 to course from dorsal distal to plantar proximal to prevent some of the dorsiflexion of the capital fragment experienced with the Ludloff version.\textsuperscript{24,25}

Modern AO/ASIF fixation methods have revived interest in the Mau osteotomy; however, the midshaft location of the osteotomy in diaphyseal bone causes healing concerns.

**Surgical Procedure**

The incision used for the Mau is similar to those for base osteotomies, but may be slightly more medially
placed. The main difference, and one of the drawbacks of this procedure, is the denuding of peristeum on the metatarsal shaft medially along almost its entire length. The peristeum must be reflected to provide exposure for the osteotomy. Care should be taken to preserve the peristeal attachments at the planar proximal and dorsal distal aspects of the metatarsal to help stabilize the resultant osteotomy.

The osteotomy is cut through both cortices from medial to lateral along an oblique line (Fig. 17-47). Once the osteotomy is complete, Patton and Zelicowski recommend using a K-wire as the "axis guide." Driven from dorsal to plantar perpendicular to the metatarsal shaft, the wire acts as a pivot point while the metatarsal head is shifted laterally to reduce the IM angle (see Fig. 17-26). Once the intermetatarsal angle has been sufficiently reduced, a bone clamp is used to preserve the correction while two screws are inserted to provide rigid internal fixation.

V-TYPE BASE OSTEOTOMY (KOTZENBERG AND LENOX BAKER)

History

Both the Kotzenberg (1929) and the Lenox Baker (1953) base osteotomies employed V-shaped cuts. Kotzenberg's V was located in the medial face of the metatarsal and the Lenox Baker was located in the dorsal face of the metatarsal. Neither of these procedures is widely employed today; they are presented mainly for historical purposes.

Surgical Procedure

In the Kotzenberg procedure, a V-shaped through-and-through osteotomy is made from medial to lateral with its apex proximal and its wings at a 45° angle (Fig. 17-48). The distal fragment is then shifted laterally and impacted on the base. This corrects the IM angle. Fixation is attained using K-wires. This is a fairly stable osteotomy and may well deserve to be more widely utilized. It also has the potential, like the distal Austin, for biplaning to help correct an abnormal PASA.

The Lenox-Baker procedure is approached dorsally and involves a V-shaped through-and-through osteotomy from dorsal to plantar with its apex distal and wings at a 45° angle. A second, more proximal cut is then made on the lateral side at 60° to the long axis of the first metatarsal. The bone wedge that is subsequently removed is used as a graft in the medial cut. As the metatarsal head is shifted laterally, closing the intermetatarsal angle, the medial cut opens, allowing insertion of the graft. The osteotomy and graft must then be fixated. We would recommend the K-wire and bone staple combination. As may be suspected, this osteotomy is technically difficult to perform and control and even more difficult to properly fixate, which explains its infrequent use (Fig. 17-49).
Fig. 17-48. (A & B) The Kotzenberg base osteotomy. Note the placement of the V-shaped cuts.
PEG-AND-HOLE BASE OSTEOTOMY (ROCYN JONES)

History

In 1948, Rocyn Jones suggested a proximal first metatarsal peg-and-hole type procedure for the correction of metatarsus primus varus in adolescents. This procedure is also provided for historical purposes because it is technically difficult to perform and commonly fails. This makes it a poor choice in light of the success achieved with other methods.

Procedure

This base osteotomy is approached dorsally. An oblique osteotomy is performed from proximal lateral to distal medial at an angle of 40° to 45° from the long axis of the first metatarsal. A second "wedge" is then cut in the distal fragment. The wedge only encompasses the medial two-thirds of the width of the metatarsal, leaving a lateral "peg." The peg is then impacted into the proximal fragment, allowing proper closure of the IM angle.
This osteotomy is obviously difficult to fixate and prone to instability, fracture, and failure. We cannot recommend this procedure, and included it merely for completeness (Fig. 17-50).

**Fixation**

In all cases, the choice of fixation for the base and head osteotomies rests with the surgeon. Options include bone staples, K-wires, Steinman pins, monofilament stainless steel wire, screw fixation with or without the use of plates following the AO/ASIF techniques, and casting, among others.

Staples are favored by the authors for their stability and ease of installation, although size must be carefully chosen to prevent fracture of the bone edges and loss of purchase (Fig. 17-51 A).

K-wires and Steinmann pins, although easy to install, can have some drawbacks. When using pins, it is preferable to use a crossed K-wire technique to guard against rotation/dorsiflexion of the capital fragment, should fracture of the cortical hinge occur. K-wires or Steinmann pins, in conjunction with staples or screws, provide a good alternative (Fig. 17-51B to D).

Monofilament stainless steel wire can be used in a four-cortex or box technique. A figure of eight or ten-

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**Fig. 17-50.** (A) The Roeyn-Jones peg-and-hole base osteotomy. (B) The completed peg-and-hole base osteotomy.
Fig. 17-51. (A) Radiograph demonstrating staple fixation of a first metatarsal base osteotomy. (B) Two 0.062 K-wires in a crossed fashion, securing a first metatarsal base wedge osteotomy. (C) Note the crossed K-wires in the closing base abductory osteotomy. Also note the bony fragment in the first interspace, demonstrating a portion of the wedge of bone that was not removed during the osteotomy. Arrow indicates loose bony body after wedge resection. (D) Combination of crossed K-wire and staple fixation.
sion technique has been utilized as well (Fig. 17-52). However, if the metal fails or the "knot" slips, fixation is lost. We have used screw or plate fixation with success; however, it is the most technically demanding option and requires previous experience and success with A/O fixation methods (Figs. 17-53 to 17-59).

Casting alone is not recommended as a fixation option, although we do recommend it strongly as an adjunct to internal fixation. Postoperatively, the patient should be placed in a non-weight-bearing short leg cast following a base osteotomy for a total of 6 to 8 weeks of immobilization.

**Fig. 17-52.** Radiograph shows monofilament wire fixation following base osteotomy.

**Fig. 17-53.** The completed Juvara base wedge osteotomy, held in place by a bone clamp. A 2.0-mm drill hole has been placed perpendicular to the osteotomy site; a countersink is now being used to allow for proper positioning of the head of the 4.0 cancellous bone screw.

**Fig. 17-54.** A depth gauge used to identify proper length of the cancellous bone screw.
Fig. 17-55. A 3.5 tap cutting the proper grooves for placement of the cancellous bone screw.

Fig. 17-56. A 4.0 cancellous (lag) screw being placed perpendicular to osteotomy site.

Fig. 17-57. Closure of IM angle and proper placement of cancellous bone screw.
Fig. 17-58. (A-C). Radiographs demonstrating closure of IM angle following Juvara base osteotomy, using 4.0 cancellous bone screw.
the first metatarsal, causes a decrease in the abductory force on the hallux by the extensor hallucis longus tendon. Therefore, the lower the postoperative IM angle, the more prone the hallux will be to drift medially. Dorsiflexion of the metatarsal head is usually caused by too much bone being removed dorsally compared to plantarly when preparing the wedge in a base wedge osteotomy. Care must also be taken in placement of the osteotomy; placement too distally in the shaft adversely affects healing, but too proximally could interfere with the metatarsocuneiform articulation.

The major complication in base osteotomies is shortening of the first metatarsal. This can lead to

**Complications**

Complications of any of the base procedures include hallux varus caused by overzealous reduction in the IM angle (Fig. 17-60). This, along with shortening of

**Fig. 17-59.** Closure of the abductory base osteotomy with screw fixation in conjunction with a hemi-implant, joint-destructive procedure at the first MTPJ.

**Fig. 17-60.** Overzealous correction of IM angle. Complete fibular sesamoidectomy resulted in hallux varus deformity.
many subsequent problems such as lesser metatarsalgia, transfer lesions, stress fractures of the lesser metatarsals, and decreased propulsive force in toe-off (called Morton's Foot syndrome). These problems often stem more from elevatus of the capital fragment than from the position or shape of the wedge resected (Fig. 17-61).

![Fig. 17-61. Improper placement of cancellous bone screws. Note the proximal screw is placed at the wrong angle to the osteotomy site, necessitating a second screw. Note also the excessive length of the distal screw and its entrance into the metatarsocuneiform joint.](image)

![Fig. 17-62. Improper fixation of a base osteotomy, resulting in non-union.](image)

As in any surgical procedure involving osteotomies, malunion or nonunion is always a possibility. This is best prevented by rigid internal fixation and external casting for the prescribed period of time (Fig. 17-62).

**SUMMARY**

Various base osteotomies have been presented in this chapter, from those used most often to those presented only for the sake of history and completeness. To review our guidelines for selecting procedures, an intermetatarsal angle (IM) greater than 12° in an adductus foot or 15° in a rectus foot calls for a base osteotomy. If the IM angle is greater than 22°, we suggest a Lapidus procedure. When an abnormal PASA is also involved with a high intermetatarsal angle, a head
procedure should be used in conjunction with a base osteotomy (Logroscino, Golden). A biplane, base, V-ostectomy may also be considered (Kotzenberg).

Metatarsal protrusion measurements must be taken into consideration before choosing a procedure. If the first metatarsal is within 2 mm of the length of the second metatarsal, a closing base wedge osteotomy (Loison and Balasescu, Juvara) can be employed. If the first metatarsal is shorter than the second by more than 2 mm, an opening base wedge osteotomy (Trehowan, Stamm), crescentic, or V-type base osteotomy is appropriate.

Ease and stability of fixation must also be taken into consideration when choosing a surgical procedure. The final choices and decisions are the responsibilities of the surgeon. Careful preoperative planning, intraoperative technique, and postoperative management should yield satisfying results. Remember, surgery is both a science and an art—do not fear being an artist.

REFERENCES