26

Surgical Management of Digital Deformities

BONNIE J. NICKLAS

All too frequently, a painful and deformed digit may be diagnosed under the commonly used terminology of "hammer toe", when in fact it may not be a hammer toe at all. Digital deformities vary widely in their presentation, severity, and etiology. To choose the best possible surgical procedure for correction of the deformity, it is critical that certain aspects of the deformity be clearly identified.

Digital deformities involving the second, third, fourth, and fifth toes can be classified and described using a number of parameters (Fig. 26-1; Table 26-1). The deformities can occur on the sagittal, transverse, or frontal planes or any combination of these planes. They may be static or dynamic and may occur singularly or as part of a group in which all lesser digits display the abnormality. They may have no planal abnormalities, that is, display no contraction or rotation, yet exhibit painful pressure lesions. If contraction or rotation is present, the contraction may be flexible and reducible, or it may be rigid and nonreducible. Etiologies of digital deformities vary widely, and may be congenital or acquired, simple or complex, the result of surgical failure or naturally occurring.

The extensive history of digital surgery includes soft tissue procedures only, osseous procedures involving partial or total resection of bone, fusions and amputations, and an untold number of combinations of these.[1-8]

Soft tissue procedures include tendon releases and lengthenings, capsulotomies, extensor hood apparatus releases, ligament releases, and tendon transfers. Tenotomies with or without capsulotomies as isolated procedures are rarely indicated. Extensor and flexor

tenotomy and capsulotomy find greatest application in the older patient in whom more definitive reconstructive surgery is not possible.[8]

Tendon transfers have been reported for a number of purposes. In 1928, Forrester-Brown used transfer of the long flexor tendon to the extensor tendons to replace lost intrinsic function to the hallux.[9] In 1942, Lapidus described transfer of the extensor tendon for correction of the overlapping fifth toe.[10] In 1947, Girdlestone transferred flexor digitorum longus tendons into dorsal expansions of the extensor tendons in the hope that intrinsic function that had been lost would be restored.[11] Sgarlato performed flexor tendon transfer to itself and to the extensor tendons for contracted digits.[12] In 1984, Barbari and Brevig performed the previously mentioned Girdlestone-Taylor with Parrish's modification.[13] In 1980, Kuwada and Dockery reported a modification of the flexor transfer in which the flexor tendon was brought through a drill hole in the anatomic neck of the proximal phalanx.[14] In 1988, Kuwada followed with a retrospective analysis of modification of the flexor tendon transfer for correction of hammer toe deformities, as a long-term look back at those performed previously.[15]

Osseous procedures include partial resection of phalanges, [1-5,16,17] total resections of phalanges, and digital amputations.[18,19] All parts of the phalanx have at one time or another been removed, including condyles, the head, the base, and the diaphyseal shaft. In 1910, Soule described the first arthrodesis procedure of the proximal interphalangeal joint (PIPJ).[20] Other modifications have included the "spike" and hole of Higgs in 1931[21] and the truncated cone-shaped design
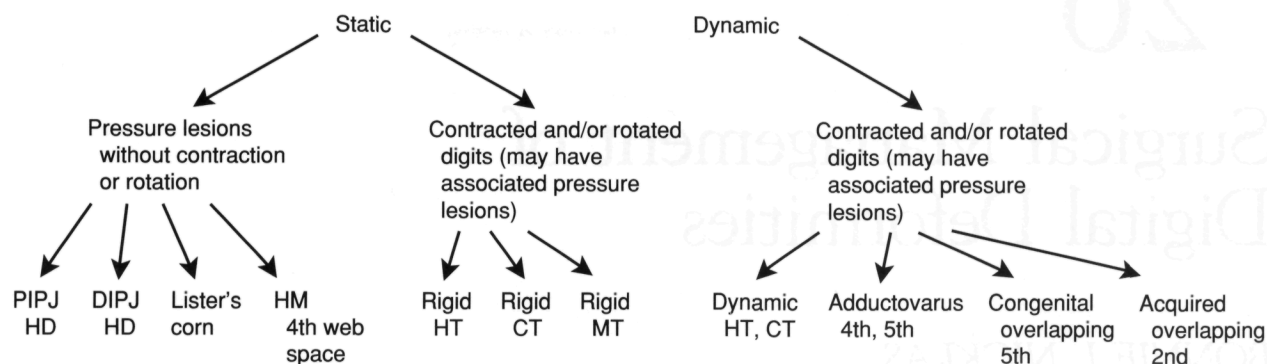
Fig. 26-1. Classification of lesser digital deformities.

Table 26-1. Classification of Digital Deformities

Type of Deformity	Etiology	Procedure of Choice	Skin Incision
Static deformities			
Pressure lesions without contraction or rotation			
PIPJ HD	Enlarged or deformed proximal phalanx	Arthroplasty, proximal phalangeal head resection	Dorsal linear
PIPJ/DIPJ HD	Enlarged or deformed middle phalanx	Arthroplasty, middle phalangectomy	Dorsal linear[a]
Lister's corn	Enlarged lateral condyle, distal phalanx	Condylectomy, lateral aspect, distal phalanx	Lazy S
Mild to moderate HM, 4th web space	Pressure: head; proximal phalanx, 5th toe at base; proximal phalanx, 4th toe	Post procedure, 5th toe; lateral condylectomy, 4th toe	Dorsal linear 4/5
Severe HM, 4th web space	Longstanding, recurrent, scar tissue	Syndactylization, 4th & 5th toes	Oval, diamond shaped
Pressure lesions with contraction			
Rigid hammer toe	Elongation, shoe gear influence, other	PIPJ arthroplasty, proximal phalanx head resection	Dorsal linear
Rigid claw toe	Elongation, shoe gear influence, other	DIPJ arthroplasty and possible middle phalangeal head resection	Dorsal linear
Rigid mallet toe	Elongation, shoe gear, fusion at PIPJ	DIPJ arthroplasty, middle phalangeal head resection	Transverse lenticular over DIPJ
Dynamic deformities with contraction and/or rotation			
Dynamic hammer toes or claw toes	Biomechanical: ext/flex subst, flex stab	PIPJ arthrodesis, 2, 3 PIPJ arthroplasty, 4, 5 with possible DIPJ arthroplasty with sequential reduction	Dorsal curvilinear extended over MPJ
Adductovarus 4th, 5th	Biomechanical: mechanical or congenital	PIPJ arthroplasty with derotational skin plasty	Oblique lenticular
Overlapping 5th	Congenital	Relocational arthroplasty	V–Y or Z-plasty
Overlapping 2nd	Acquired	Relocation/reduction with stabilization PIPJ arthroplasty or arthrodesis	Dorsal curvilinear

Abbreviations: PIPJ, proximal interphalangeal joint; HD, heloma durum; DIPJ, distal interphalangeal joint; HM, heloma mollé.
[a] Over time, dynamic, flexible deformities can become static and rigid due to malignment of joints leading to articular damage.
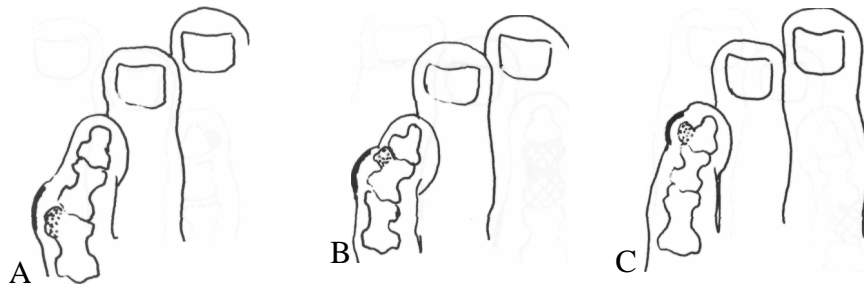
Fig. 26-2. (A) Proximal interphalangeal joint (heloma durum). **(B)** Distal interphalangeal joint (heloma durum). **(C)** Lateral nail fold (Lister's corn).

of Young in 1938.[22] Although spiked and pointed at the tip, Higgs' was the first peg-in-hole type of procedure. In 1980, Alvine and Garvin described a peg-and-dowel fusion of the PIPJ.[23] Although peg and dowel are synonymous terms, their procedure was similar to that described by Young.[22] Today the two most commonly performed fusion procedures include the end-to-end and peg-in-hole PIPJ arthrodesis.

This chapter formulates and puts into use a practical and workable classification system for the most commonly seen digital deformities, using as a general template the type, etiology, and apex of the deformity; this is followed by the procedure of choice for correction of all components of the deformity, including the skin incision, and technique of the procedure in a step-by-step fashion, and concludes with postoperative treatment plan designed around the specific needs of that procedure. Following classification of the deformity, description of appropriate surgical procedures, and followup care, the author provides a discussion and rationale for each of the plans undertaken.

STATIC DEFORMITIES: PRESSURE LESIONS WITHOUT CONTRACTION OR ROTATION

Heloma Dura

Clinical Presentation and Etiology

When a patient presents with painful heloma dura on an otherwise normal-appearing toe, the apex can be the PIPJ (heloma durum) (Fig. 26-2A), the distal interphalangeal joint (DIPJ) (heloma durum) (Fig. 26-2B), or the lateral nail fold (Lister's corn) (Fig. 26-2C). The

etiology is an enlarged or deformed proximal or middle phalanx, or an enlarged lateral condyle-distal phalanx.

Procedure of Choice

The procedure of choice is the removal of the appropriate osseus segment. For an enlarged or deformed proximal phalanx, an arthroplasty and head resection of the proximal phalanx should be performed. For an enlarged or deformed middle phalanx, an arthroplasty and head resection of the middle phalanx or middle phalangectomy should be performed. A condylectomy should be performed for an enlarged lateral condyle of the distal phalanx.

Technique

The incision for an arthroplasty and head resection of the proximal or middle phalanx is dorsal linear. A lazy S incision, which begins dorsally and curves distally and laterally, may be used for a condylectomy (Fig. 26-3).

Before surgery, hyperkeratotic tissue of the heloma durum is debrided, taking particular care not to "nick" or create abrasions in underlying healthy skin. Perform the appropriate skin incision, and dissect down through subcutaneous tissue to the level of the extensor digitorum longus tendon. Identify the appropriate joint and transect the tendon. Perform a capsulotomy and release collateral ligaments to free the bone of all soft tissue attachments. Using power or manual instrumentation, resect the head of the proximal or middle phalanx. When performing a middle phalangectomy, the middle phalanx must be carefully freed from all
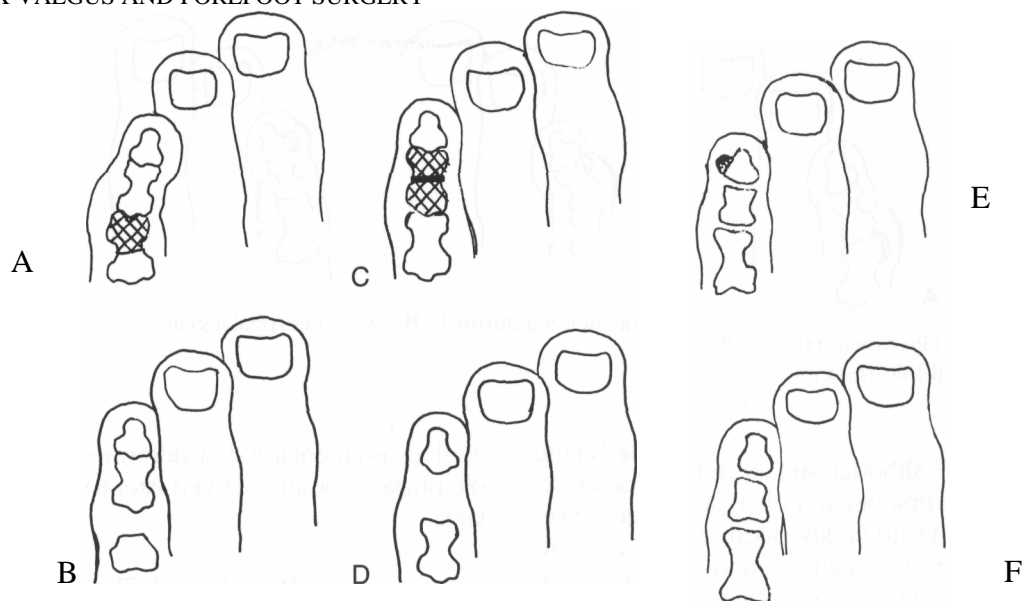
Fig. 26-3. (A & B) Arthroplasty involving head resection of proximal phalanx. **(C & D)** Arthroplasty involving head resection of middle phalanx or middle phalangectomy. **(E & F)** Condylectomy of lateral condyle of distal phalanx.

soft tissue attachments at both the PIPJ and DIPJ and removed in toto.

For digits that also display a callus formation at the lateral nail fold secondary to an enlarged lateral condyle of the distal phalanx, the dorsal linear incision can be curved distally, laterally, and plantarly to end over the lesion at the lateral nail fold. The incision is deepened, and careful dissection will expose the lateral condyle, which is resected.

The surgical sites are irrigated and tendon repair is performed with 3-0 absorbable suture material. Subcutaneous tissues that require approximation are repaired with 4-0 absorbable material, and skin closure is accomplished with 5-0 nylon or polypropylene on a plastic surgery tipped needle.

Postoperative Management

Immediately after surgery the digit is splinted and a forefoot dressing is applied. Three to five days postoperatively, the dressing is changed and a new sterile dressing applied. The patient is seen in 1 week (10 to 12 days postoperative). The sutures are removed, and the digit is placed into splint or dressing. The patient is

seen again in 1 week (17 to 19 days postoperative), the dressings are discontinued and only splinting materials used. The patient is seen at 4 weeks and 6 weeks postoperative and splinting of the digit is continued. At 6 weeks postoperative, the surgical shoe may be changed to an athletic-type or walking shoe. Postoperative radiographs should be taken immediately after surgery and at 6 weeks, 3 months, and 6 months to evaluate alignment and osseous regrowth.

Discussion and Rationale

Selective arthroplasty of the proximal or distal interphalangeal joints is a very successful and gratifying procedure for the patient with an uncomplicated, noncontracted or nonrotated digit. These painful digital deformities are the result of extrinsic pressure over a bony prominence, and have nothing to do with biomechanics or pathomechanics. Purely a pressure phenomenon, they respond well to removal of the offending osseous segment. Care must be taken in determining the apex of the deformity, and in deciding on the best course of action for that particular deformity or combination of deformities. Oftentimes a

Fig. 26-4. Mild to moderate heloma molle, fourth web space.

small, painful Lister's corn will accompany a larger, more proximal lesion, and care should be taken to ascertain each and every factor causing symptomatology in the digit and address each factor individually.

Mild to Moderate Heloma Molle

Clinical Presentation and Etiology

The patient presents with a mild to moderate heloma molle in the fourth web space (Fig. 26-4). The apex is a painful heloma molle deepseated in the fourth web space, and a radiographic lesion marker may be needed. The lesion is pressure related, usually occurring between the head of the fifth proximal phalanx and the base of the fourth proximal phalanx.

Procedure of Choice

The procedure of choice is a proximal phalangeal head resection of the fifth digit *and possible* lateral condylectomy of the base of the proximal phalanx of the fourth digit.

Technique

A dorsal curvilinear incision is made over the fifth digit and extended proximally to the metatarsophalangeal joint (MPJ) (Fig. 26-5A). Perform a proximal phalangeal head resection of the fifth digit, as described for painful heloma durum and simple anthroplasty, over the PIPJ (Fig. 26-5B). Perform a lateral condylectomy of the base of the fourth proximal phalanx, which can usually be done through the same incision. Remodel, irrigate, and close the tissue layers as previ-

ously described for simple arthroplasty (Fig. 26-5C). Take postoperative radiographs to evaluate alignment and position (Fig. 26-5D).

Postoperative Management

Postoperative management is the same as for simple arthroplasty; however, care is taken to splint both the fourth and fifth toes. The remainder of postoperative management is the same.

Discussion and Rationale

The heloma molle deformity is a very painful condition that responds well to properly selected surgical procedures.[24] A decision must be made regarding the necessity to remove the lateral condyle from the fourth proximal phalanx. This can usually be determined on the basis of the size and extent of the lesion preoperatively and by radiographic findings. When the lateral condyle is a contributing factor, generally there will be evidence of enlargement or abnormal contour on radiography, as well as a skin lesion that extends beyond the deep web space. It is as important as choosing the correct procedure that the surgical site should be carefully prepared, free of macerated, necrotic tissue, and the base should be carefully inspected for the presence of sinuses, drainage, or inflammation.

Severe, Recurring Heloma Molle

Clinical Presentation and Etiology

When the patient presents with severe, recalcitrant, and recurring heloma molle of the fourth web space, the apex is deep seated in the web space with additional lesions or extensions of lesions on the inside surface of the toes. The lesions are pressure related, with contributions from the fourth and fifth proximal phalanges. The lesions may be long standing and recurrent, with scar tissue buildup. The lesions may have been operated previously or have become previously infected.

Procedure of Choice

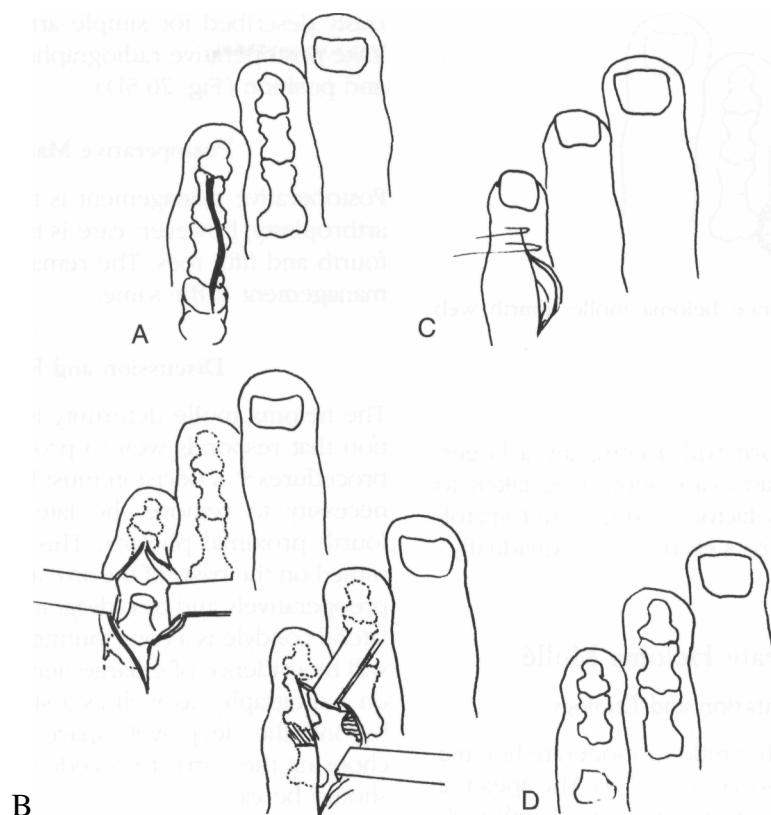The procedure of choice is syndactylization of the fourth and fifth toes.

Fig. 26-5. (A) Dorsal curvilinear incision over the fifth digit; incision extended proximally to the metatarsopha-langeal joint. **(B)** Proximal phalangeal head resection of the fifth digit, over the proximal interphalangeal joint. Lateral condylectomy performed at the base of the fourth proximal phalanx, using the same incision. **(C)** Remodeling, irrigation, and closure of tissue layers. **(D)** Final alignment and position.

Technique

An interdigital, diamond-shaped or oval (double U) incision is made. Prepare the surgical site as described for the previous procedure. Using a sterile skin scribe, mark the area of skin flap removal on the inner surface of one of the digits. With the ink still wet, gently touch the two inner surfaces of the digits together, creating a mirror image on the opposite side (Fig. 26-6A). Using a #15 blade, circumscribe the area indicated by the ink, taking care not to skive the edges. Remove the entire flap of skin, taking care to remove only epidermis and dermis, leaving all subcutaneous tissue intact. From within the wound, carefully dissect to the level of bone, free up soft tissue attachments at the PIPJ, and remove an appropriate segment of bone (Fig. 26-6B)

As determined preoperatively, remove the lateral condyle from the base of the four proximal phalanx if appropriate. Following remodeling and irrigation as needed, place suture materials in skin, across the flap, but leave the flap in place until all sutures are placed. Using hand-tie methods, complete final square-knot ties with an assistant supporting the fifth toe in the proper position. All ties are completed, and tags are left longer than usual for easy removal (Fig. 26-6C). Take postoperative radiographs to evaluate alignment and position (Fig. 26-6D).

Postoperative Management

The postoperative management is similar to that of the simple arthroplasty without significant variation.
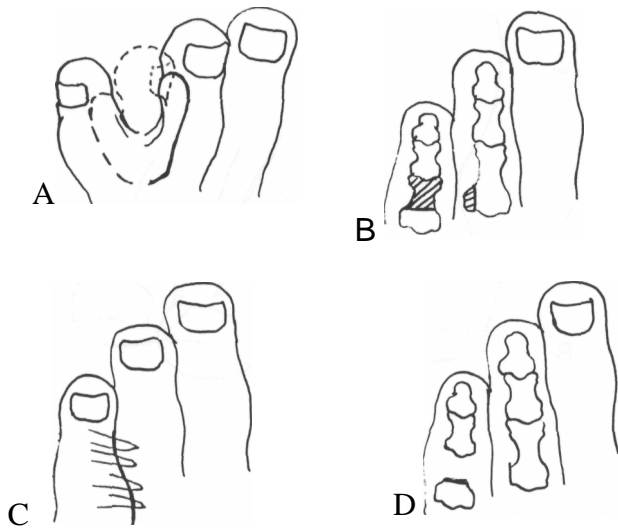
Fig. 26-6. (A) Area for skin flap removal marked using sterile scribe. With the ink still wet. the inner surfaces of the digits are gently touched together, creating a mirror image on the opposite sides. **(B)** Appropriate segment of bone removed. **(C)** Sutures are placed and completed using final square knots hand-tied with aid of assistant. **(D)** Final alignment and position.

Discussion and Rationale

Although it may appear simple and harmless to a patient, a heloma molle in any web space can become locally infected, and may undergo rapid progression into the deep plantar spaces of the foot; it is therefore particularly dangerous in the diabetic foot. This deformity should be carefully evaluated and aggressively treated, both conservatively and surgically. Some important points to remember when performing the procedure are precise mapping-out of the skin flap and careful removal of the skin, leaving all subcutaneous tissue intact for maximum healing potential. Additional comments include the specific technique used for skin closure, as difficulties have been encountered when a single suture is tied before placement of all other sutures. Placement across the skin flap, then hand-tying all sutures at once, avoids the difficulty encountered in passing a needle through tissue with the toe relocated.

Syndactylization is an excellent procedure for the severe, recalitrant heloma molle that has been unre-

sponsive to conservative or surgical care.[25-30] It is also an excellent choice for the "flail toe" that may result from surgical failure, tissue loss from infection, or trauma.

STATIC DEFORMITIES: PRESSURE LESIONS WITH CONTRACTION (SAGITTAL PLANE DEFORMITIES)

Rigid Hammer Toe

Clinical Presentation and Etiology

When a patient presents with rigid hammer toe with a painful heloma durum, the apex is the PIPJ. By definition, there is dorsiflexion at the MPJ, plantar flexion at the PIPJ, and dorsiflexion at the DIPJ. The etiology can be an elongated digit, shoe gear pressure, or other extrinsic structures.

Procedure of Choice

The procedure of choice is arthroplasty with proximal phalangeal head resection.

Technique

A dorsal linear incision is made. The simple arthroplasty is performed in a similar fashion as previously described without significant variation (Fig. 26-7). Following resection of the proximal phalangeal head, the phalanx is evaluated to determine whether it is adequately relocated on the sagittal plane to the level of the adjacent digits.

Postoperative Management

The postoperative treatment plan is that described previously for the simple arthroplasty technique.

Discussion and Rationale

Arthroplasty via proximal phalangeal head resection is an excellent procedure for the simple, uncomplicated, rigid hammer toe deformity, and is usually very successful in alleviating the problem. As this is purely a sagittal plane contracture, the dorsal linear incision is adequate to provide exposure to vital areas of concern without damage to the neurovascular structures. Al-
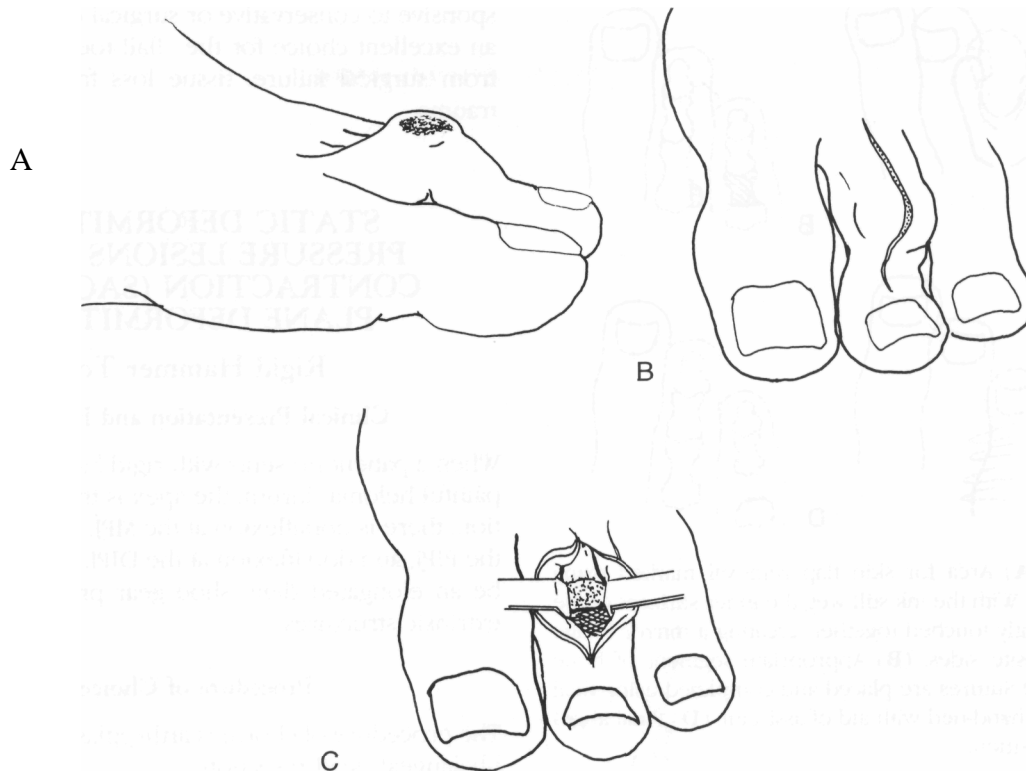
Fig. 26-7. (A) Isolated hammer toe deformity. **(B)** Skin incision. **(C)** Proximal phalangeal head resection.

though the digit is dorsiflexed at the MPJ, there is generally no need for additional procedures beyond resection of the proximal phalangeal head to relocate the digit. In most cases, reduction of the bone content by resection of the head provides the space necessary to correct the contracture. As this is a rigid deformity, one can often visualize degenerative changes in the joint, even to the degree that initial dissection into the joint for delivery of the head may be difficult because of partial fusion of the joint. If this procedure does not reduce the contraction at the MPJ, sequential reduction is performed.

Rigid Claw Toe

Clinical Presentation and Etiology

When the patient presents with rigid claw toe with painful heloma durum (Fig. 26-8), the apex is the PIPJ,

but the DIPJ may also be involved. By definition, there is dorsiflexion at the MPJ and plantar flexion at the PIPJ and DIPJ. There may be an associated distal clavus if clawing of the digit is severe. The etiology can be an elongated digit, shoe gear pressure, or neuropathy.

Procedure of Choice

The procedure of choice is arthroplasty with proximal phalangeal head resection and possible middle phalangeal head resection.
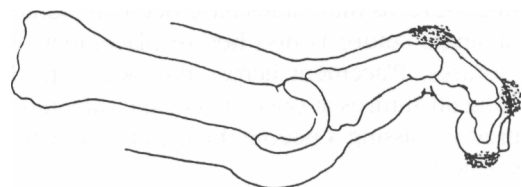

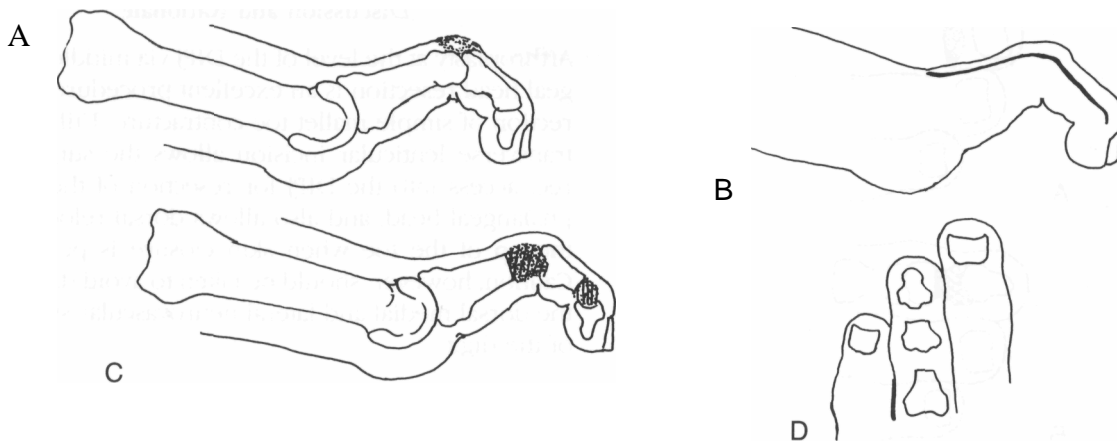**Fig. 26-8.** Rigid claw toe with painful heloma durum.

Fig. 26-9. (A) Rigid claw toe deformity. **(B)** Skin incision. **(C)** Appropriate sections of bone are resected. **(D)** Corrected digit.

Technique

A simple arthroplasty (Fig. 26-9) is performed in a similar fashion as previously described without significant variation. Following this procedure, an intraoperative decision is made to perform a similar procedure at the level of the DIPJ. This is occasionally necessary.

Postoperative Management

The postoperative treatment plan is that described previously for the simple arthroplasty procedure.

Discussion and Rationale

Arthroplasty at the level of the PIPJ is an excellent procedure for the simple, uncomplicated rigid claw toe deformity, with results comparable to that of simple hammer toes. Occasionally deformity of plantar flexion may occur at the level of the DIPJ that is not reduced following the proximal procedure. In that case, arthroplasty at the level of the DIPJ may be necessary. Particular attention should be given to the plantar skin of a long-standing claw toe deformity, as it may exhibit shortening subsequent to contracture; this may disallow straightening of the digit without a larger amount of bone resection than was previously expected or additional skin plasty techniques for the purpose of lengthening the skin. Failure to address the

shortened plantar skin could result in damage to the soft tissue structures including nerves and vascular and lymphatic structures from excessive stretching, which could lead to loss of the digit.

Rigid Mallet Toe

Clinical Presentation and Etiology

When the patient presents with rigid mallet toe with painful distal clavus, the apex of the deformity is in the DIPJ, over which a heloma durum can form. However, the patient's chief complaint may be focused around a painful distal clavus that develops subsequent to the plantar flexion of the digit at the DIPJ, making it, by definition, a mallet toe contracture. The etiology can be an elongated digit or shoe gear pressure, or it may have developed secondary to PIPJ fusion.

Procedure of Choice

The procedure of choice is arthroplasty with middle phalangeal head resection.

Technique

A transverse lenticular or fusiform incision is made over the DIPJ (Fig. 26-10A). Utilizing a sterile skin scribe, the planned incisional approach is mapped out over the DIPJ. Using a #15 blade the incision is per-
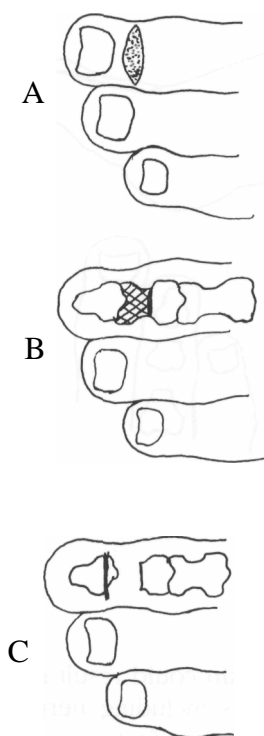
Fig. 26-10. **(A)** Transverse lenticular incision over distal interphalangeal joint. **(B)** Head of middle phalanx is resected and the remaining portion is remodeled. **(C)** Closure of the tendon, capsule, and skin are completed.

formed in the designated area, and the skin flap is removed, including all epidermis and dermis, leaving all subcutaneous tissue intact. Dissection is carried through the subcutaneous tissue to the level of the deep fascia and extensor tendon. The tendon is transected at the level of the DIPJ; capsulotomy is performed, collateral ligaments are transected, and the head of the middle phalanx is delivered through the operative site. The head of the middle phalanx is now resected using power or manual instrumentation (Fig. 26-10B). The remaining portion of the middle phalanx is remodeled, and after irrigation of the operative site, closure of the tendon, capsule, and skin are completed (Fig. 26-10C). Postoperative radiographs are taken to evaluate alignment and position.

Postoperative Management

The postoperative treatment plan is the same as that described for the simple arthroplasty procedure.

Discussion and Rationale

Arthroplasty at the level of the DIPJ via middle phalangeal head resection is an excellent procedure for correction of simple mallet toe contracture. Utilizing the transverse lenticular incision allows the surgeon direct access into the DIPJ for resection of the middle phalangeal head, and also allows dorsal relocation of the tip of the toe when skin closure is performed. Caution, however, should be taken to avoid damage to the dorsal medial and lateral neurovascular structures of the digit.

DYNAMIC DEFORMITIES: DEFORMITIES WITH CONTRACTION OR ROTATION

Clinical Presentation and Etiology

The patient with dynamic hammer toes or claw toes presents with MPJ dislocation with associated dorsal proximal or PIPJ irritations or calluses. The etiology is biomechanical, caused by extensor substitution, flexor substitution, or flexor stabilization.

Procedure of Choice

The procedure of choice is digital relocation with stabilization via sequential reduction and digital arthroplasty/arthrodesis procedures.

Technique

A dorsal curvilinear incision is centered over the digit, extending proximally to the level of the MPJ (Fig. 26-11A). Deepen the incision through the subcutaneous tissue using light brushing strokes to the level of the deep fascia and extensor hood apparatus. Perform a Z-plasty tendon-lengthening procedure on the extensor digitorum longus, reflecting one end proximally and the other end distally, and exposing the PIPJ of the digit (Fig. 26-11B). The tendon may be transected at the level of the PIPJ if the contracture is not severe enough to warrant Z-plasty lengthening.

Perform release of all soft tissue attachments and deliver the proximal phalangeal head through the surgical site. At this time, osseous procedures are performed (Fig. 26-11C).

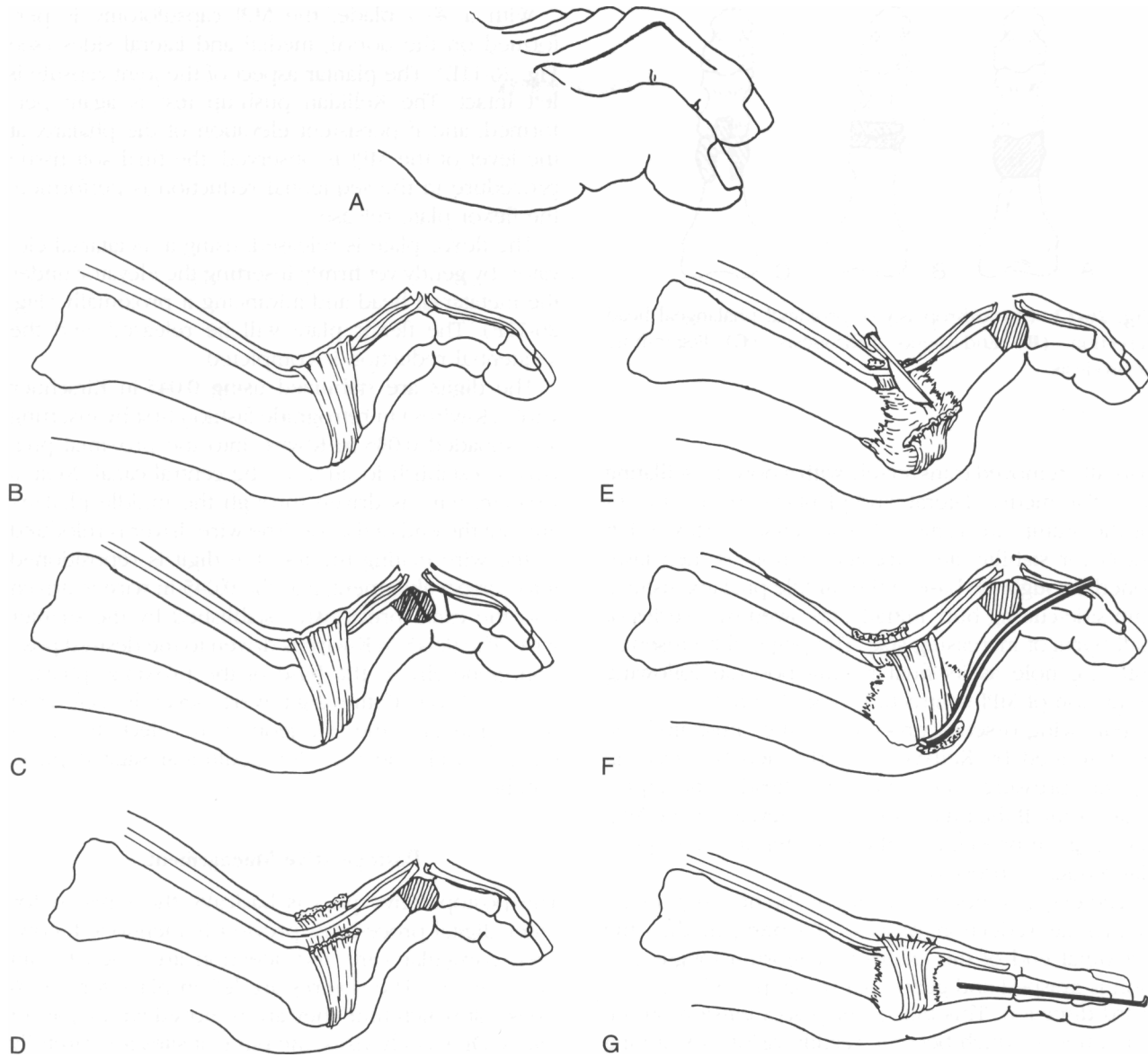*Arthroplasty.* If the procedure of choice is the arthroplasty, the proximal phalangeal head is now re-

Fig. 26-11. (A) Dorsolinear skin incision. **(B)** Z-plasty lengthening of extensor digitorum longus tendon. **(C)** Head resection (partial or total) of proximal phalanx. **(D)** Extensor hood recession. **(E)** Metatarsophalangeal joint capsulotomy. **(F)** Flexor plate release. **(G)** Kirschner-wire stabilization.

sected, whether by manual or power instrumentation. The remaining stump is remodeled and irrigated (Fig. 26-12A).

Arthrodesis. If the procedure of choice is the arthrodesis, the appropriate sections of bone are removed.

For an end-to-end fusion, the cartilaginous surface of the proximal phalangeal head and middle phalangeal base are resected using manual and power instrumentation (Fig. 26-12B). If a peg-in-hole arthrodesis is being performed, the head of the proximal phalanx is
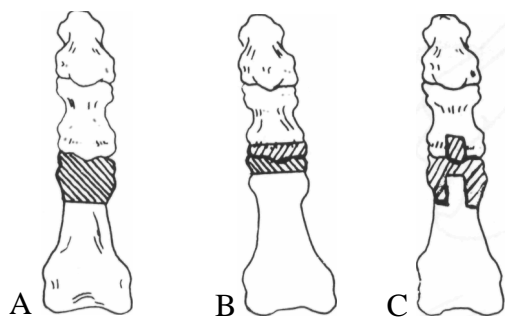
Fig. 26-12. (A) Arthroplasty of proximal phalangeal head resection. **(B)** End-to-end arthrodesis. **(C)** Peg-in-hole arthrodesis.

partially removed transversely with a power oscillating saw. The medial, lateral, and plantar cortical surfaces of the stump are removed. The dorsal cortex is left intact for stability and strength. A hole is then fashioned through the base of the middle phalanx, using a thin side-cutting burr initially, followed by a series of ball burrs of increasing size. The peg will be inserted into the hole as its final resting position following reduction of MPJ contracture (Fig. 26-12C).

Following osseous procedures, the "push-up" test as described by Kelikian is performed by directing upward pressure on the metatarsal head at the appropriate joint. If the phalanx remains elevated at the MPJ, the surgeon proceeds to the next step in the sequential reduction process.

The extensor hood recession is the next step in the sequential reduction process. To perform this, the proximal end of the extensor digitorum longus tendon is grasped and gently but firmly pulled in an upward direction. This maneuver places tension on the hood fibers, which become readily visible, exhibiting their perpendicular arrangement to the extensor tendon. The fibers of the hood are released in a sweeping-type motion using a #15 blade, keeping the scalpel blade parallel with the tendon. Particular care is taken to avoid penetration into the delicate tendon sheath, or damage to the periosteum of the metatarsal (Fig. 26-11D). This completes the extensor hood release. The Kelikian push-up test as previously described is again performed, and with persistent dorsiflexion of the proximal phalanx on the MPJ, the next step is undertaken, which is the MPJ capsulotomy.

With a #64 blade, the MPJ capsulotomy is performed on the dorsal, medial and lateral sides (see Fig. 26-1 IE). The plantar aspect of the joint capsule is left intact. The Kelikian push-up test is again performed, and if persistent elevation of the phalanx at the level of the MPJ is observed, the final soft tissue procedure in the sequential reduction is performed: the flexor plate release.

The flexor plate is released, using a metatarsal elevator, by gently yet firmly inserting the elevator under the metatarsal head and advancing it proximally (Fig. 26-11F). The flexor plate will be released, and the sequential reduction is completed.

The digits are stabilized using 0.045-in. Kirschner wires (K-wires) in retrograde fashion first by inserting an unloaded 0.035-in. K-wire into the proximal phalanx to establish location of the central canal. Next, a 0.045-in. wire is driven through the middle phalanx and out the end of the toe. The wire driver is relocated to the wire exiting the toe, the digit is repositioned into correct alignment, and the 0.045-in. wire is driven into the canal previously established by the smaller wire. The 0.045-in. K-wire is driven to the desired position, generally to the base of the proximal phalanx (Fig. 26-11G). If the digit were severely deformed preoperatively, the surgeon may elect to cross the MPJ with the wire for additional sagittal plane stability.

Postoperative Management

The postoperative plan is basically the same as for other digital procedures previously mentioned; however, particular care and attention are given to pin management. The K-wires are left in place for 4 to 6 weeks, at which time they are removed with a pair of pliers. On weekly visits, the pin exit sites are carefully inspected for tuft blanching, inflammation, or drainage. They are cleansed at each visit, with a new application of antibiotic ointment placed at the base of the pin to seal the opening. Radiographs are taken immediately following surgery, then at 3 and 6 weeks postoperatively to monitor osseus healing. Light compression splints are utilized to avoid swelling of the digits as the patient's activity level increases and when the sutures and pins are removed. Occasionally, removal of the pins may cause mild temporary swelling of the toe.

Discussion and Rationale

Contracted digits demonstrating dislocation at the level of the MPJ are a special circumstance in which all aspects of the deformity must be addressed or the surgery is doomed to failure. The chief complaint in these patients is often lesser metatarsalgia, and frequently submetatarsal calluses are observed. If the apex of the deformity, however, lies in the contracture of the digit at the level of the MPJ and IPJ(s), the surgeon must recognize the correct etiology and address the problem appropriately. Oftentimes the etiology is related to intrinsic muscle wasting (Fig. 26-13). In this case it would not be advisable to perform lesser metatarsal osteotomies before alleviating the symptoms through digital reduction and stabilization. Generally this is all that is required to successfully convert the very painful, unstable forefoot into a nonpainful, stable forefoot. It is essential that the physician recognize which symptoms are primary and which are secondary so that the correct surgical procedures may be selected. The arthroplasty is generally performed on those digits where flexibility at the PIPJ is necessary. The end-to-end arthrodesis is generally performed in those digits that are mildly contracted, have some dynamic component, and are of normal length. The peg-in-hole procedure is generally performed on those digits that are severely contracted, have a significant dynamic component, and are excessively long. The peg-in-hole procedure provides significant shortening capabilities by its design. Sequential reduction will correct all the soft tissue contractures that are significant deforming forces proximally, and allow the digit to be returned to proper alignment in the sagittal plane. K-wire stabilization will provide the temporary support necessary to allow for healing in the corrected position.

When this procedure is performed correctly, it is very successful and very gratifying to the patient. This type of severe digital deformity is typically very painful and may even be disabling. Stabilizing the digits through this complex repair restores some of the stability that has been lost, allowing improved function of the digits, better propulsion in gait, and improved alignment of the metatarsal heads in the sagittal plane individually and the transverse plane collectively. When all the lesser toes are addressed as a group, the second and third toes are generally arthrodesed, while
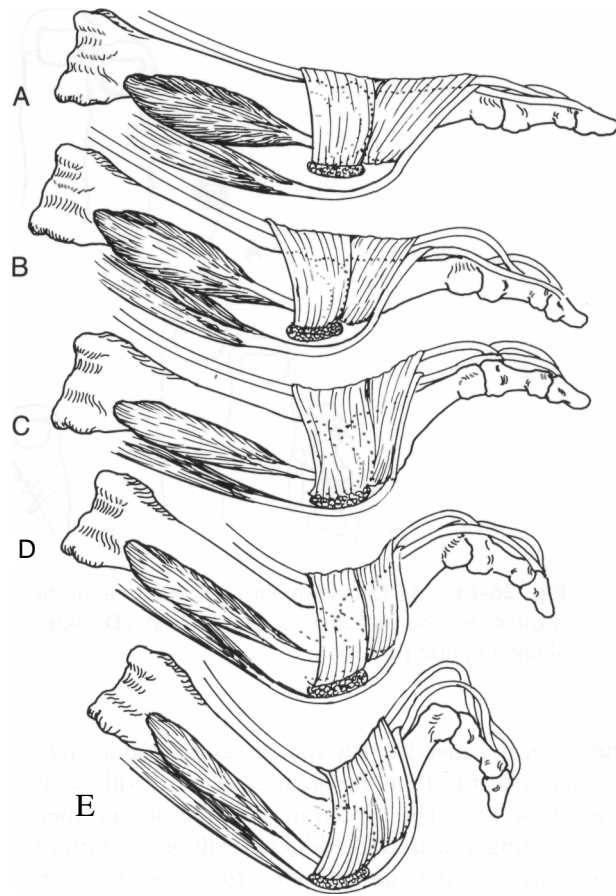

Fig. 26-13. (A-E) Contraction of digits leading to plantar flexion of metatarsal heads. Note wasting of intrinsic musculature.

the fourth and fifth toes undergo arthroplasty procedures. The fifth toe is never arthrodesed.

The sequential reduction of complex claw toe and hammer toe deformities, described by Jimenez et al., is an excellent method for reducing several digital contractures and often eliminates accompanying metatarsalgia secondary to digital dislocation.[31,32]

Adductovarus Deformity of the Fifth Toe

Clinical Presentation and Etiology

When a patient presents with adductovarus deformity of the fifth toe, the apex is the proximal IPJ, and occasionally the distal IPJ as well. The etiology can be bio-
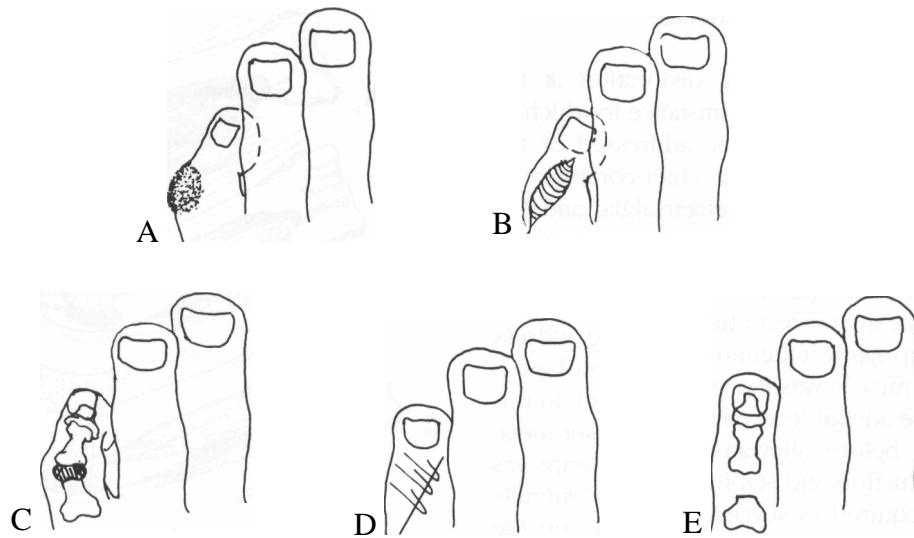
Fig. 26-14. **(A)** Debridement of hyperkeratotic tissue of the heloma durum. **(B)** Lenticular skin incision. **(C)** Arthroplasty via proximal head resection. **(D)** Skin closure with digit supported in corrected position. **(E)** Final alignment and position.

mechanical, caused by the quadratus plantae losing its normal vector pull on the digits associated with pronation of the foot. The direction of pull is shifted medi-ally, creating a varus and adductus pull on the fifth toe. The fourth toe may also develop the same deformity. The etiology can also be mechanical because of extrinsic pressure from shoe gear influencing malalignment of the digit. Some authors believe there are also congenital factors.

Procedure of Choice

The procedure of choice is the PIPJ arthroplasty with head resection using derotational skin plasty technique.

Technique

An oblique lenticular or fusiform incision is made. Carefully debride hyperkeratotic tissue of the heloma durum to determine the extent of the lesion (Fig. 26-14A), using caution not to nick or abrade the skin. Before drawing the intended incision with a sterile skin scribe, gently derotate the digit and lightly pinch the skin in the area of the skin incision. In performing

this maneuver, the surgeon can visualize the dimensions of the skin ellipse to be removed.

Using a sterile skin scribe, mark the skin ellipse to be removed. The skin incisions will be two converging semielliptical incisions placed in a proximal-lateral to distal-medial direction over the lesion (Fig. 26-14B). This "lenticular" incision will result in derotation of the digit as the skin flap is removed and skin edges are reapproximated. Important considerations are to remove all epidermis and dermis and leave intact all subcutaneous tissue for vascular supply to the skin, to maximize healing potential and maintain a 3:1 length-to-width ratio of dimensions for the flap.

Following removal of the skin flap, dissection is carried down to the level of the deep fascia and extensor tendon, and an arthroplasty via proximal head resection is performed in the manner previously described (Fig. 26-14C).

The tendon and capsule are repaired in the usual fashion, and skin closure is then accomplished with an assistant supporting the digit in the corrected position (Fig. 26-14D). On closure of the skin, the digit should be derotated and rest in an upright position with its alignment restored. Postoperative radiographs are taken to evaluate alignment position (Fig. 26-14E).
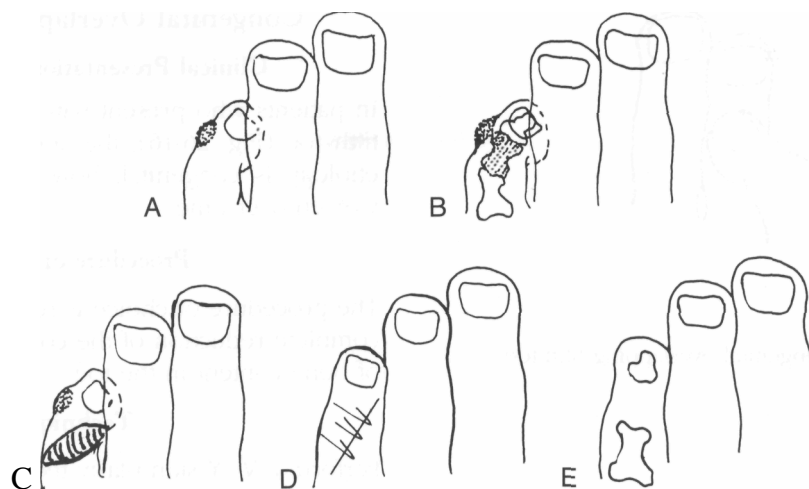
Fig. 26-15. **(A)** Adductovarus digit with apex at the middle phalanx. **(B)** Middle phalangectomy. **(C)** Lenticular incision centered over the apex. **(D)** Skin closure with digit supported in corrected position. **(E)** Alignment and final position.

Postoperative Management

The postoperative management is the same as that described for the simple arthroplasty; however, particular care is taken to maintain the digit in a derotated position using dressings and splints.

Discussion and Rationale

The adducto varus deformity of the fifth toe, and less often of the fourth toe, is very common. Because of its position, extrinsic shoe pressure frequently leads to hyperkeratotic tissue formation in the form of heloma dura, over the dorsal or dorsolateral aspect of the digit. The fifth toe is particularly subject to this type of repetitive trauma because of its location and size. The derotational arthroplasty is an excellent way to achieve precise realignment of the digit and removal of underlying bony prominences.[33] The same deformity can occur in the fourth digit if medial vector forces are strong enough. Preoperative radiographic lesion markers are excellent in assisting the surgeon to precisely identify the apex of the deformity if it is unclear on clinical examination.

Middle Phalangectomy

A modification of this procedure can be performed if the apex of the deformity is actually in the middle phalanx (Fig. 26-15A), rather than the proximal phalanx, as is usually the case.[4,5] In this situation the middle phalanx is generally enlarged or abnormal in contour and shape, and may be removed in toto (Fig. 26-15B).

Technique

The procedure is identical to that previously described with the following exceptions. The skin ellipse is performed slightly distal to that previously mentioned, as the apex of the deformity is now in the middle phalanx (Fig. 26-15C). The dissection is carried to the level of the deep fascia and extensor tendon, at which the capsulotomy of the PIPJ is performed. The middle phalanx is freed of all soft tissue attachments by sharp dissection, and it is removed. The remainder of the procedure is similar to that of the aforementioned procedure, and postoperative management treatment plans are similar as well (Fig. 26-15D and E).

Discussion and Rationale

Middle phalangectomy is an excellent procedure for the adductovarus deformity of the fourth or fifth digit where the apex of the deformity is clearly at the level of the middle phalanx. Careful preoperative evaluation of the radiographs in such a situation will usually demonstrate a middle phalanx that is enlarged or ab-

Fig. 26-16. Congenital overlapping fifth toe.

normally contoured. It is interesting to note that the section of bone removed when removing an entire middle phalanx is generally approximately the same as the amount of bone removed with the head of the proximal phalanx.

Congenital Overlapping Fifth Toe

Clinical Presentation and Etiology

In patients who present with congenital overlapping fifth toe (Fig. 26-16), the apex is the fifth MPJ. The etiology is congenital, however, the deformity can worsen over time.

Procedure of Choice

The procedure of choice is relocation of the digit via complete reduction of the contracture and reduction of bone content in the toe.

Technique

Perform a V-Y skin plasty technique over the MPJ in line with the contracture (Fig. 26-17A). Create a flap, dissect down through the subcutaneous tissue to the level of the deep fascia, and locate the extensor digi-torum longus tendon. Perform Z -plasty lengthening, then reflect the tendon ends, one distally and one
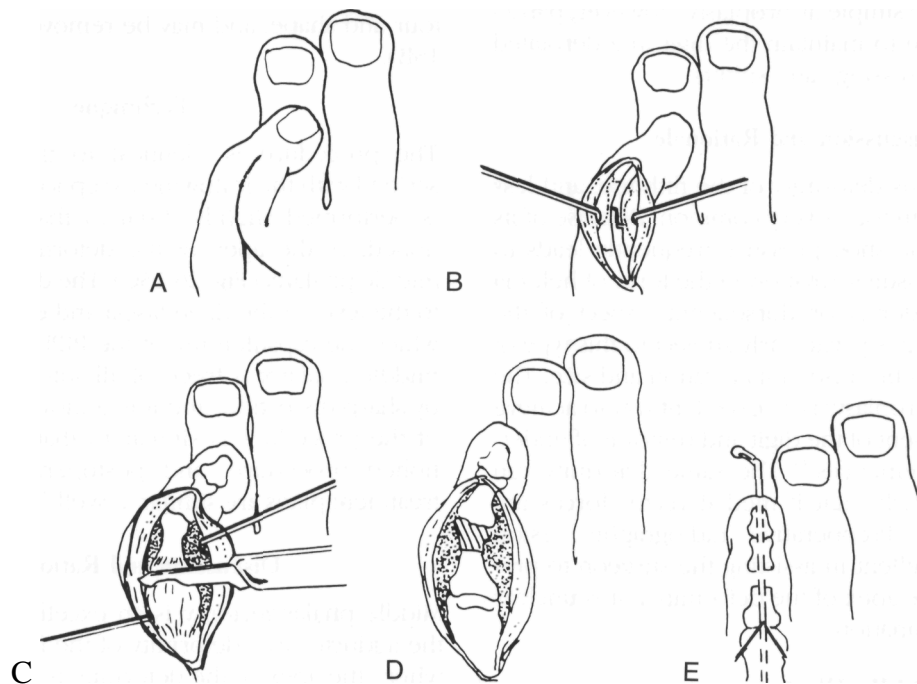

Fig. 26-17. (A) V-Y skin plasty over the metatarsophalangeal joint. **(B)** Z -plasty, lengthening the extensor digitorum longus tendon. **(C)** Capsulotomy of the fifth metatarsophalangeal joint. **(D)** Arthroplasty via proximal phalangeal joint. **(E)** Postoperative Alignment and final position.

proximally (Fig. 26-17B). Locate the fifth MPJ. Using a #64 blade, perform a medial, dorsal, and if necessary, lateral, capsulotomy of the MPJ (Fig. 26-17C).

Perform a dorsal linear incision, either separately, or by extending the arm of the V to Y (short Y to long Y), centered over the fifth digit. In the fashion previously described, perform an arthroplasty technique via proximal phalangeal head resection (Fig. 26-17D). Irrigate the surgical site, and complete the procedure with K-wire stabilization by retrograde fashion across the MPJ. Closure of soft tissue structures and skin is now accomplished in the usual fashion. Postoperative radiographs are taken to evaluate alignment and position (Fig. 26-17E). Note: alternative incisional approach includes dorsal linear over the digit and Z-plasty to lengthen skin contracture.

Postoperative Management

The postoperative treatment plan for relocation of the congenital overlapping fifth toe is essentially the same as for that of any digital procedure in which K-wires are exiting the digits. The pin may be removed from across the MPJ at 3 to 6 weeks, and is usually left in place in the digit for 4 to 6 weeks.

Discussion and Rationale

Because of significant malalignment, the overlapping fifth toe is particularly prone to injury and trauma, which may result in callus or ulcer formation. Historically, many procedures have been designed and modified to address this deformity with incomplete success.[10,18,34-41] Failure was most likely attributed to a series of incomplete approaches because not all components of the deformity (i.e., shortened dorsal skin, shortened extensor digitorum longus tendon, contracted MPJ capsule, and normal bone content) were addressed. Rather, each attempt was only partially complete and resulted in only partial success. It is also interesting to note that, although the digit itself is relatively normal with the exception of its malaligned position at the MPJ, it must have some bone removed; in other words, it is necessary to decrease the internal cubic content of bone to relocate the digit. Failure t o do this will most likely place an excessive amount of tension on the digit and stretch the delicate neurovascular structures beyond their capacity for survival.
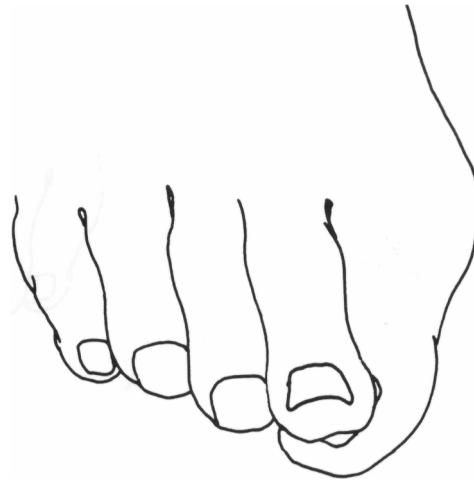

Fig. 26-18. Acquired overlapping second digit.

Acquired Overlapping Second Digit

Clinical Presentation and Etiology

For a patient presenting with an acquired overlapping second digit (Fig. 26-18), the apex is the MPJ and IPJs of the digit. The etiology is variable. If may originate in the digit itself, or it may be the result of other space-occupying structures taking its place (e.g., the hallux).[42-44]

Procedure of Choice

The procedure of choice is relocation of the digit via sequential reduction at the MPJ, realignment and stabilization at the digital interphalangeal joints, and stabilization of periarticular structures around the MPJ.

Technique

A dorsal curvilinear incision is centered over the digit and extended proximally to curve over the MPJ (Fig. 26-19A). The procedure is as previously described for relocation and stabilization of severe hammer toe and claw toe deformities with the following additional procedures.

Following completion of the usual reduction of the digit, attention is directed to the flexor structures in an attempt to realign the flexor tendon sheath back into normal position under the metatarsal head (Fig. 26-19B). It is well accepted by most authorities that the adductus component is caused by a shift of the flexor
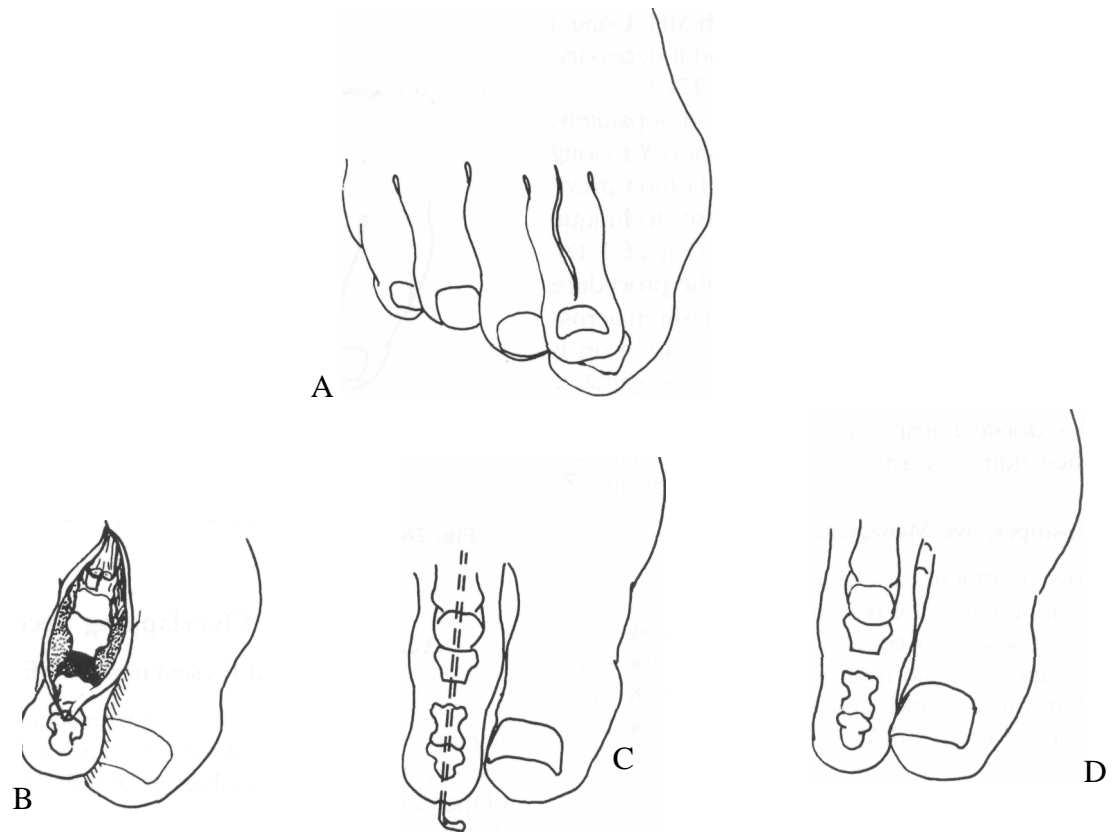
Fig. 26-19. (A) Dorsal curvilinear skin incision. **(B)** Realignment of flexor tendon sheath below the metatarsal head. **(C)** K-wire stabilization. **(D)** Postoperative alignment.

structures in addition to the sagittal plane contracture of the digit; this has been shown by flexor tenogram technique. The goal, then, is to realign and stabilize these flexor structures, or it is likely that the digit will not maintain a corrected position in the long term. K-wire stabilization is performed by retrograde technique (Fig. 26-19C).

Postoperative Management

The postoperative treatment plan is essentially the same for this procedure as for the complex hammer toe repair previously described. It is likely that the K-wire will be placed in retrograde fashion, extending across the MPJ. Following removal, the digit is evaluated as to its sagittal plane and transverse plane stability (Fig. 26-19D).

Discussion and Rationale

Rationale for this procedure is similar in philosophy, success, and repair to that for complex hammer toes. The challenging component and least predictable outcome of the procedure is the long-term stability of the adductus component of the deformity.

REFERENCES

1. Sorto LA: Surgical correction of hammer toes, a five year postoperative study. J Am Podiatry Assoc 64:930, 1974
2. Johnson CP, Hugar DW: A literature review of congenital digiti quinti varus: clinical description and treatment. J Foot Surg 22:116, 1983
3. Sokoloff HM: Soft tissue digitial procedures. Clin Pod Med Surg 3:23, 1986

4. Jenkin WM: Arthroplasty via intermediate phalangectomy. Clin Pod Med Surg 3:41, 1986

5. Dobbs BM: Arthroplasty of the fifth digit. Clin Pod Med Surg 3:29, 1986

6. Monson DK, Buell TR, Scurran BL Lesser digital arthrodesis. Clin Pod Med Surg 3: 1986

7. McGlamry ED, Jimenez AL, Green DR: Lesser ray deformities, p. 341. In McGlamry ED (ed): Comprehensive Textbook of Foot Surgery. 2nd Ed. Williams & Wilkins, Baltimore, 1992

8. McGlamry ED: Lesser ray deformities. Comprehensive Textbook of Foot Surgery. 2nd Ed. Williams & Wilkins, Baltimore, 1992

9. Forrester-Brown MF: Tendon transplantation for clawing of the great toe. J Bone Joint Surg 20:57, 1938

10. Lapidus PW: Transplantation of the extensor tendon for correction of the overlapping fifth toe. J Bone Jojnt Surg 24:555, 1942

11. Girdlstone GR: Physiology for the foot and hand. J Bone Joint Surg 29:167, 1947

12. Sgarlato TE: Transplantation of the flexor digitorum longus muscle tendon in hammer toes. J Am Podiatry Assoc 60:383, 1970

13. Barbari SG, Brevig K: Correction of clawtoes by the Girdlestone-Taylor flexor-extensor transfer procedure. Foot Ankle 5:67, 1984

14. Kuwada GT, Dockery GL Modification of the flexor tendon transfer procedure for the correction of flexible hammertoes. J Foot Surg 19:38, 1980

15. Kuwada GT: A retrospective analysis of modification of the flexor tendon transfer for correction of hammer toe. J Foot Surg 27:57, 1988

16. Post AC: Hallux valgus with displacement of the smaller toes. Med Rec NY 22:120, 1882

17. Terrier: Orteils en marteau avec durillons et bourses sereuses sousjacentes enflammees. Resection des deux Cotes, et dans la meme seance, de Larticulation phalango phalangeinne. Bull Mem Soc Chir 14:624, 1888

18. Kelikian H: Hallux Valgus, Allied Deformities of the Forefoot and Metatarsalgia. p 327. WB Saunders, Philadelphia, 1965

19. Friend G: Correction of elongated underlapping lesser toes by middle phalangectomy and skin plasty. J Foot Surg 23:470, 1984

20. Soule RE: Operation for the cure of hammer toe. New York Med J pp 649-650, March 26, 1910

21. Higgs SL: Hammer-toe. Med Press 131:473, 1931

22. Young CS: An operation for the correction of hammer-toe and claw-toe. J Bone Joint Surg 20:715, 1938

23. Alvine FG, Garvin KL: Peg and dowel fusion of the proximal interphalangeal joint. Foot Ankle 1:90, 1980

24. Zeringue GN, Harkless LB: Evaluation and management of the web corn involving the fourth interdigital space. J Am Pod Med Assoc 76:210, 1986

25. Strach EH, Cornah MS: Syndactylopoiesis: a simple operation for interdigital soft corn. J Bone Joint Surg 54:530, 1972

26. Kurtz CM, Guthrie JD: Syndactylization: a surgical approach to heloma molle. J Foot Surg 23:407, 1984

27. Hoffman GA: Plastic web reconstruction for soft corn of fourth interspace. J Nat Assoc Chirop 39:22, 1949

28. Bottnick S: Surgical syndactylizm for heloma molle, a case report. J Am Pod Assoc 54:411, 1964

29. Kelikian H. Clayton, L, Loseff H: Surgical syndactylia of the toes. Clin Orthop 19:219, 1961

30. Bernback E: A surgical procedure to syndactylize. J Am Pod Assoc 46:447, 1956

31. McGlamry ED: Lesser ray deformities, p. 349. In: Comprehensive Textbook of Foot Surgery. 2nd Ed. Williams and Wilkins, Baltimore, 1992

32. Nicklas BJ: Prophylactic surgery in the diabetic foot, p. 526. In Frykberg R (ed): The High Risk Foot in Diabetes Mellitus. Churchill Livingstone, New York, 1991

33. McGlamry ED, Lesser ray deformities, p. 354. In: Comprehensive Textbook of Foot Surgery. 2nd Ed. Williams and Wilkins, Baltimore, 1992

34. Anderson BV: Combination surgery for overlapping fifth digit. J Am Pod Assoc 61:137, 1971

35. Cockin J: Butler's operation for an overriding fifth toe. J Bone Joint Surg Br 50:78, 1968

36. Du Vries HL: Surgery of the Foot. CV Mosby, St. Louis, 1959

37. Goodwin FC, Swisher FM: The treatment of congenital hyperextension of the fifth toe. J Bone Joint Surg 25:193, 1943

38. Jahss MH: Diaphysectomy for severe acquired overlapping fifth toe and advanced fixed hammering of the small toes. p. 211. In Batemen JR (ed): Foot Science. WB Saunders, Philadelphia, 1976

39. Kaplan EG: A new approach to the surgical correction of overlapping toes. J Foot Surg 3:24, 1964

40. Lantzounis LA: Congenital subluxation of the fifth toe and its correction by a periosteocapsuloplasty and tendon transplantation. J Bone Joint Surg 22:147, 1940

41. Wilson JN: V-Y correction for varus deformity of the fifth toe. BrJ Surg 41:133, 1953

42. Coughlin MJ: Crossover second toe deformity. Foot Ankle 8:29, 1987

43. Branch HE: Pathologic dislocation of the second toe. J Bone Joint Surg 19:978, 1937

44. Johnson JB, Price IV TW: Crossover second toe deformity: etiology and treatment. J Foot Surg 28:417, 1989