CLAWTOE DEFORMITIES AND CONTRACTURES OF THE FOREFOOT

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Purpose

There are definite indications and surgical techniques of tendon surgery as they relate to clawtoe deformities and contractures of the forefoot. Clawtoe is is a complex deformity often associated with cavus foot deformity and neuromuscular disorders. The surgeon must have a thorough understanding of the etiology and biomechanics of pes cavus to fully understand the pathomechanics of clawtoe deformity. A detailed discussion of pes cavus is beyond the scope of this paper and the reader is referred to the chapter on pes cavus in *Comprehensive Textbook of Foot Surgery,* volume 1, Chapter 8, edited by E. Dalton McGlamry, 1987 edition.

Most investigators agree that tendon transfers alone will rarely correct a clawtoe or associated cavus foot deformity. In most cases a combination of tendon surgery and osseous procedures are utilized. Subsequent paragraphs will review in detail the procedures utilized for correction of both the flexible and fixed clawtoe deformity. Emphasis will be placed on correction of the fixed deformity using a combination of tendon procedures and osseous procedures for correction. The disadvantages of tendon surgery as isolated procedures in treatment of clawtoes is compared to the effectiveness of various osseous procedures.

Definition and Classification

Clawtoe deformity is a complex deformity which is often associated with the cavus foot type and neuromuscular disorders. Hammertoes, clawtoes, and contractures of the digits are best treated by a systematic approach. Tendon surgery does not correct fixed or osseous clawtoe deformities; however, it may be effective in removing deforming forces in the early stages of a progressive deformity. It is essential that the surgeon determine the type of deformity whether flexible or rigid and also the progression of the deformity in selecting the appropriate surgical procedure for correction.

A useful test in determining the flexibility of deformity is the push-up test. In the early or flexible stages of clawtoe deformity the toe will straighten upon weightbearing. This can also be determined in a non-weight-bearing position as the surgeon performs the push-up test by loading the forefoot with pressure applied beneath the metatarsal heads. In the flexible digital deformity the digit will straighten to a corrected position upon performance of the push-up test. In the fixed or later stages the digit will fail to straighten (Fig. 1). Thus, the degree of fixed deformity can be determined by range of motion examination and by the push-up test as described.

The fixed deformity or rigid deformity is characterized by flexion of the proximal interphalangeal joint and extension of the metatarsophalangeal joint with regardless of loading of the forefoot.

Clawtoe deformity most often involves all the lesser toes, however, the hallux is involved in a large percentage of patients with a more severe deformity. The clawtoe deformity is a severe progressive deformity in contrast to the isolated hammertoe deformity. Clawtoe deformity is characterized by deformity in which the middle and distal phalanges are flexed on a markedly dorsiflexed proximal phalanx and with dorsal contracture of the metatarsophalangeal joints (Fig. 2).

Clinically this condition may also appear with painful metatarsalgia beneath the metatarsal heads with intractable plantar keratosis. In many cases dorsal lesions or heloma dura are noted on the dorsal aspect of the digits secondary to shoe irritation and pressure. As the clawtoe deformity progresses late changes including degenerative arthritic changes with dislocation of the metatarsophalangeal joints are characteristic. These clinical findings can be demonstrated by radiographic changes which will vary with the degree of deformity and rigidity of the clawtoe deformity.

In the flexible digital deformity, non-weight-bearing radiographs will demonstrate the dorsiflexed position of the digits. In a weight-bearing radiograph the digits will be in a more rectus alignment.

In the later stages of clawtoe deformity or in the fixed deformity, the deformities usually are worsened upon weightbearing and can be readily demonstrated on the weight-bearing radiograph. Radiographic findings in this condition reveal a dorsiflexed position of the proximal phalanges and plantarflexion of the middle and distal phalanges. The typical positive gun barrel sign is readily apparent on the dorsoplantar view in the presence of the severe clawtoe deformity (Fig. 3).

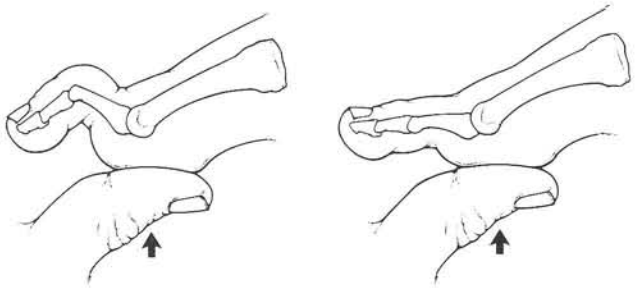

Fig. 1. The push-up test is simple method for determining degree of rigidity in digital deformity. **A.** Depicts rigid digital deformity. **B.** Represents reducibility of flexible clawtoe with metatarsophalangeal joint loading.

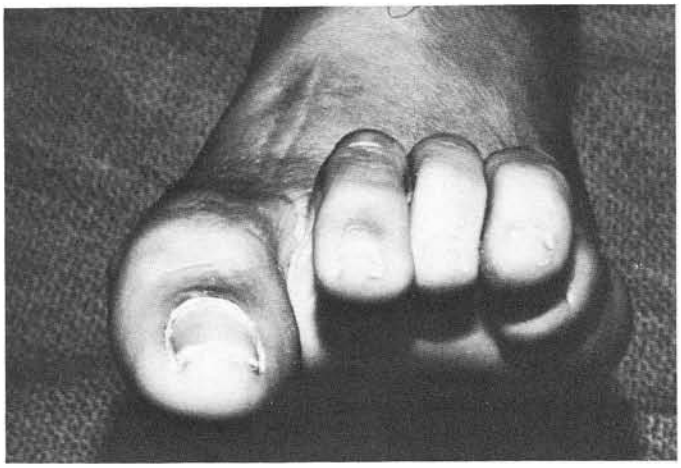

Fig. 2. Severe clawtoes and hallux interphalangeal flexion deformity associated with neurologically induced cavus foot deformity.

Fig. 3. "Gun-barrel" sign is seen in this dorsoplantar radiograph of a patient with clawtoe deformities.

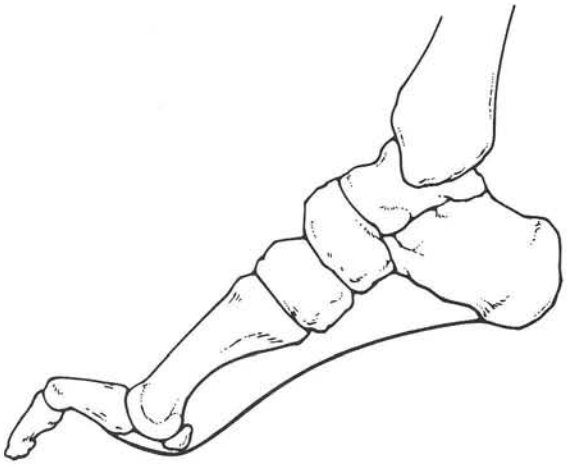

Fig. 4. Illustration depicts association of cavovarus deformity with retrograde force of digit on metatarsal. Additionally, dorsiflexion of proximal phalanx causes plantar fascia to be put on stretch further increasing cavus deformity.

Clawtoe deformity is characterized by retrograde buckling at the metatarsophalangeal joints. This greatly increases trauma to the metatarsal heads. The degree of retrograde buckling is determined by the degree and progression of the digital deformity. In many instances the clawtoe deformity may progress to the point of total dislocation of the metatarsophalangeal joints. Clawtoe correction eliminates retrograde buckling force from the metatarsophalangeal joints and will assist in correcting flexible forefoot cavus deformities (Fig. 4).

Surgical Technique For Correction of Flexible Digital Deformities

Goals and Indications

The major goal in the correction of digital deformities is to achieve a rectus digit which is asymptomatic and is flexible enough to absorb shock during gait and to provide for normal propulsion and toe off. It is not only important to restore the rectus alignment of the digits but also to establish stability of the digits to resist recursion or progression of the deformity.

Various tendon procedures are indicated in the correction of digital deformities when the primary deforming force is flexible (soft tissue).

The procedures that follow are described for correction of the flexible digital deformity:

1. Extensor tenotomy and capsulotomy
2. Flexor tenotomy and capsulotomy
3. Flexor tendon transfer

4. Jones tendon suspension
5. Hibbs tendon suspension
6. Heyman extensor tendon transfers

Extensor Tenotomy and Capsulotomy

Indications: Extensor tenotomy and capsulotomy as an isolated procedure has limited applications in correction of digital deformities. In the geriatric patient who cannot undergo reconstructive surgery the deformity can be corrected with this simple procedure. The procedure is a simple release procedure which may alleviate pain and relieve pressure from footgear in the elderly patient who is ambulating on a limited basis. Its most appropriate application is on the patient who displays an apropulsive gait.

Procedure: The procedure is usually performed under local anesthesia through a small linear incision of one to two cm directly over the tendon at the level of the metatarsophalangeal joint. Through this incision, the extensor tendon to the digit is identified and tenotomized under direct visualization.

Once the tendon has been severed the toe is placed under distal traction to a normal position. With the toe held in a distracted position, the capsule of the metatarsophalangeal joint can easily be palpated. With all vital structures retracted the capsule of the metatarsophalangeal joint is incised medially, laterally, and dorsally. Care is taken to avoid damage to the articular cartilage of the joint. The wound is thoroughly irrigated with sterile saline followed by closure of each layer.

Aftercare: Postoperatively the digit is held in a corrected position with bandaging for 3-4 weeks followed by the use of a digital splint or retainer for at least 10-12 weeks. Early return to foot gear with adequate toe box space helps to maintain correction of the deformity. An appropriate retainer may help maintain the corrected position and also to serve as a splint at night.

Extensor tenotomy and metatarsophalangeal joint capsulotomy are relatively atraumatic procedures; however, they should not be viewed as a completely innocuous. The surgeon must be aware of the loading phenomenon which occurs when a tenotomy is performed which results in an increased load on the remaining extensor tendons to the digits. In many cases, it is best to perform a tenotomy of the extensor tendons to all lesser digits rather than a single, double, or triple tenotomy. This minimizes potential for loading phenomenon and its effect on the remaining digits (Fig. 5).

Flexor Tenotomy and Capsulotomy

Indications: Flexor tenotomy and capsulotomy of the interphalangeal joint is usually combined with extensor tenotomy and metatarsophalangeal joint capsulotomy. It is rarely performed as an isolated procedure. This procedure is similar to the extensor tenotomy and capsulotomy is indicated in the geriatric patient where reconstructive surgery is unwise. Tenotomy of the flexor tendons of a digit will sacrifice the ability of the toe to purchase the ground during gait. This could present a problem in a young patient who still possesses a propulsive gait. In the geriatric patient who has difficulty ambulating and has an apropulsive gait the procedure may be of benefit in alleviating pain and re-establishing alignment of a digit.

Procedure: The procedure is performed through a plantar stab incision directly beneath the interphalangeal joint. Through this incision, the surgical blade is rotated to face the plantar aspect of the flexor tendon and as the toe is placed under tension, the tendons and capsule are severed. The interphalangeal joint is manipulated into hyperextension and the deep and superficial layers are closed in the usual manner.

Aftercare: The aftercare following flexor tenotomy and capsulotomy is similar to that prescribed previously for the extensor tenotomy and capsulotomy. Following 3-4 weeks of surgical bandaging and splinting, a retainer or splint is utilized to hold the digit in a corrected position.

In the geriatric patient this procedure when appropriately performed and followed with orthodigital control can provide a satisfactory postoperative result with minimal surgical trauma. Although digital purchase is sacrificed with this procedure it is rarely a problem in the geriatric patient who usually functions with an apropulsive gait.

Flexor Tendon Transfers

Indications: The flexor tendon transfer is a soft tissue procedure for correction of flexible digital contraction. The procedure utilizes transfer of the long flexor to the dorsum of the proximal phalanx for correction of loss of intrinsic function of the digit. Most clinicians agree that the procedure is only of benefit to patients with mild digital deformities which are flexible in nature.

An alternative to flexor tendon transfer is arthrodesis of the proximal interphalangeal joint. This stabilizes the toe and effectively restores the flexor function of both flexor tendons.

Review of patients having previously undergone flexor tendon transfer indicates several cautions. It is common to see recurrence of deformity. In other instances a rocker-bottom toe may develop as an overcorrection. The procedure is often inadequate to eliminate retrograde buckling at the metatarsophalangeal joint.

Procedure: The surgical approach is usually through two kin incisions. The first incision is placed on one side of the

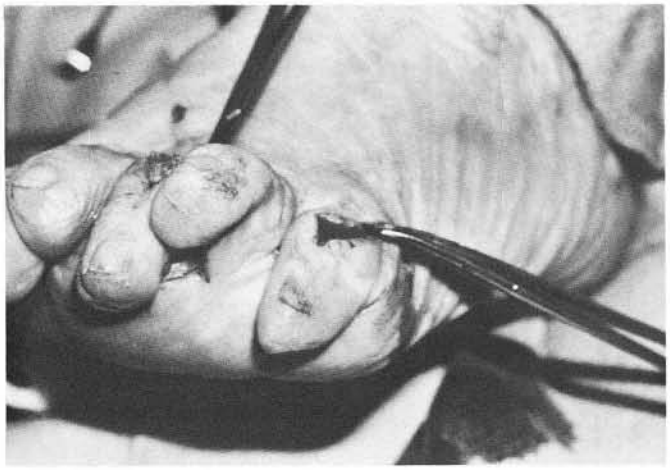

Fig. 5. Loading phenomenon is depicted in extensor tendon to fourth digit following tenotomy of remaining lesser digits.

Fig. 6. Radiograph illustrates osseous erosion common in flexor tendon transfers. Revision of clawtoe correction was necessary because of reverse buckling deformity which resulted at proximal interphalangeal joint of this digit.

digit, usually medially in the case of the second toe and laterally on the third, fourth, and fifth toes in order to provide the greatest exposure. The second incision is made dorsomedially or dorsolaterally but on the opposite side of the toe from the first incision. Both incisions are deepened to the level of the periosteum. Care is taken to avoid trauma to neurovascular structures. Through the first incision, the flexor longus tendon is identified and exposed distally and severed close to its attachment to the distal phalanx in order to preserve as much length as possible.

The long flexor tendon is split longitudinally back to the shaft of the proximal phalanx. One half of the tendon is tagged with a straight hemostat and the other half with a curved pediatric hemostat. Following channeling of to connect the two incisions along the periosteum, the medial and lateral halves of the flexor tendon are brought out the dorsal incision crossed over the phalanx to create a sling. They are sutured with a 3-0 non-absorbable suture while holding the digit in a position of correction. Any excess tendon is excised and the wound is closed.

Flexor tendon transfers are best suited for the flexible digital deformities. Complications following the procedure include excessive swelling and decreased range of motion and often stiffness. In occasional cases postoperative edema may last for several months and may produce difficulty in wearing foot gear. Overcorrection of the deformity has been a problem in isolated cases in which the toe developed a reverse deformity with painful pressure occurring under the head of the proximal phalanx. Absorption of bone or whittling of bone by the transferred tendon and fracture of the proximal phalanx has been noted in isolated cases of flexor tendon transfer (Fig. 6).

An alternative to the procedure is arthrodesis of the interphalangeal joints of the three middle toes. The flexor tendon transfer is a more appropriate procedure for correction of the flexible fifth toe deformity which should not be arthrodesed because of potential problems with shoe irritation following arthrodesis.

Jones Tendon Suspension

Indications: The Jones tendon suspension is an isolated tendon transfer involving transfer of the extensor hallucis longus to the neck of the first metatarsal in the presence of a flexible plantar flexed first ray. This procedure is commonly used to correct overpowering of the ray by the peroneus longus and flexor hallucis longus muscles. The Jones tendon suspension will actively dorsiflex a flexible first ray thus releasing the retrograde force of the hallux. It should be noted that this procedure has limitations and does not correct any fixed or rigid deformity.

In most cases, hallux flexion deformity at the interphalangeal joint is a fixed or rigid deformity requiring an osseous fusion in order to correct the deformity. The recommended procedure in such instances is arthrodesis of the interphalangeal joint of the hallux. Such arthrodesis usually eliminates retrograde force of the hallux from the metatarsal head. In rare instances both hallux interphalangeal joint arthrodesis and Jones tendon suspension may be needed.

Hibbs Tendon Suspension

Indications: The Hibbs tendon suspension was originally described as a transfer of the combined extensor tendons to the third cuneiform for correction of flexible digital deformities. The original technique also included a plantar fascial release.

We have modified the procedure to include the following:

1. Transfer of the extensor digitorum longus tendons to the second or third cuneiform
2. A Jones transfer of the extensor hallucis longus tendon to the first metatarsal neck
3. Anastomosis of the distal stumps of the long extensor tendons to the extensor digitorum brevis tendons
4. Omission of the plantar release

With the above modifications the Hibbs procedure has been an effective non-osseous procedure for correction of flexible digital deformities. The procedure does maintain flexor stability to the digits and assists in loading the mid-tarsal joint in dorsiflexion.

The Hibbs tendon suspension has limited application in digital surgery or correction of the clawtoe deformity. Forefoot deformities may be reduced with this procedure only if the deformity is flexible in nature.

More often the treatment of choice in these conditions is proximal interphalangeal joint arthrodesis. The arthrodesis is combined with metatarsophalangeal joint release for correction of the digital deformity and the reverse buckling of the toe against the metatarsal heads (Fig. 7).

It should be pointed out that overloading of the transferred tendons in a Hibbs procedure can result in the development of lesser metatarsophalangeal joint limitus. This condition is every bit as disabling as its counterpart hallux limitus. One guards against this possibility by avoiding the temptation to load the tendons as they are transferred into the lesser tarsal area.

Heyman Extensor Transfer Procedure

Indications: Our modification of the Heyman procedure involves transfer of all five long extensor tendons into their respective metatarsal heads. The procedure is indicated only in the correction of the flexible digital deformity. As modified the procedure to includes anastomosis of the distal stumps of the long extensor tendons into the respective short extensor tendons.

The Heyman procedure and its modifications are rarely used today. The procedure is technically difficult to perform and requires excessive surgical dissection and trauma. Most surgeons agree that alternative procedures are advantageous. The alternative of choice at Doctors Hospital is interphalangeal joint arthrodesis with metatarsal joint capsulotomy and extensor hood recession.

Complications of the Heyman procedure can include neurovascular compromise, soft tissue slough due to extensive dissection through multiple parallel incisions, lesser metatarsophalangeal joint limitus and recurrent hammertoe deformity. One common but unexpected finding is regeneration of the transposed extensor tendons across the gap from the metatarsal head to the toe. With the regeneration comes fixed contracture of the metatarsophalangeal joint. Because of the foregoing potential problems the procedure finds scant use today.

Osseous Procedures for Correction of Clawtoe Deformities Arthroplasty Proximal Interphalangeal Joint

Arthroplasty of the proximal interphalangeal joint is indicated in the correction of a flexible to semi-rigid digital deformity. Removal of a portion of the head of the phalanx

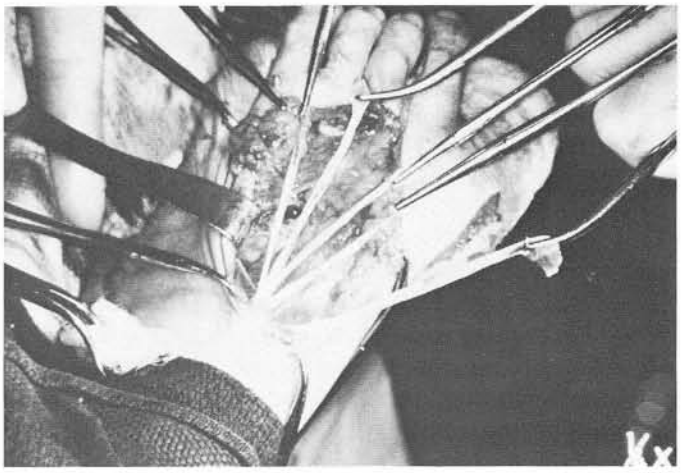

Fig. 7. Extensive dissection is required for Hibb's suspension. This procedure finds decreased use today.

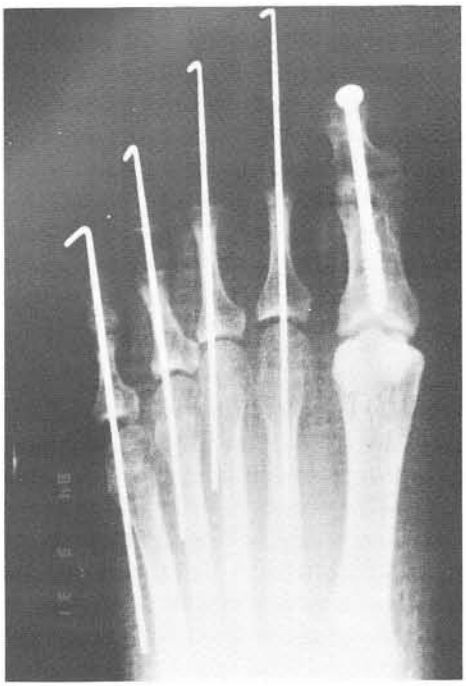

Fig. 8. Kirschner wire stabilization plays an important role in maintaining digital alignment.

in this procedure effectively produces shortening of the toe and relaxes the soft tissues thus decreasing the deforming forces and providing slack in the extensor and flexor tendons.

Technique: The procedure can be performed through a linear or transverse incision made at the level of the proximal interphalangeal joint (Fig. 8). The incision is carried deeply through the level of the subcutaneous tissues to the level of the deep fascia covering the extensor tendons. Care is taken to avoid trauma or injury to the neurovascular structures which are preserved and retracted. The extensor tendons are undermined and retracted to the medial or lateral side of the joint. The digit is then flexed while the medial and lateral collateral ligaments are incised and the head of the proximal phalanx delivered from the wound.

The head of the phalanx is resected at the appropriate level depending upon the amount of shortening necessary to relieve the soft tissue tension while maintaining a straight or rectus position of the digit. Following resection of the head, the remaining bone is smoothed with a rotary burr.

An alternative technique to retraction of the extensor tendon is incision of the tendon at the level of the proximal interphalangeal joint. Incision of the tendon at this level provides adequate exposure to the head of the proximal phalanx. Following removal of the appropriate amount of bone the incised extensor tendon is then repaired with 3-0 absorbable suture while holding the toe in a corrected position. Subcutaneous tissue and skin are closed in the usual manner.

The arthroplasty as described is used at both the proximal and distal interphalangeal joints. It is one of the most commonly used procedures for correction of digital deformities. Arthroplasty of the proximal interphalangeal joint, depending upon the amount of bone removed, will release the tension of both extensor and flexor tendons which are major deforming forces in the hammertoe condition. The surgeon must consider the possible loading effect to the tendons of the adjacent digits. Overall the results of arthroplasty of the proximal interphalangeal joint have been gratifying.

Aftercare: Postoperative care following arthroplasty of the proximal interphalangeal joint includes bandaging and splinting of the corrected toe in a position of correction for 4-6 weeks. When adjacent digits are corrected, supportive bandaging may be necessary for a longer period of time. Postoperative edema is common and should be treated appropriately with compressive dressings and early return to foot gear.

Peg in Hole Arthrodesis

Indications: Peg in hole arthrodesis is indicated in the correction of fixed or osseous deformity involving the digits. It is especially helpful in providing the tendons with a stable lever arm to enhance metatarsophalangeal joint. One of the main advantages of the peg in hole arthrodesis is its inherent stability and the ease with which arthrodesis occurs. While internal fixation is not essential we, nonetheless, feel more secure with a K-wire for increased stability. The peg in hole arthrodesis may be indicated in the correction of either flexible or rigid clawtoe deformity.

Technique: The procedure is performed through a linear, transverse or two transverse semi-elliptical incisions. The incision is deepened via sharp dissection to the level of the deep fascial covering of the extensor tendons. The tendon is divided by a Z-plasty. The tendon ends are then retracted proximally and distally isolating the interphalangeal joint. The medial, lateral, and plantar condyles are resected from the head of the phalanx. The dorsal cortex is preserved to provide stability of the peg. A hand held K-wire is used to open the canal of the proximal phalanx. This will facilitate later placement of intramedullary fixation.

The base of the middle phalanx is drilled to the appropriate length and circumference to accommodate the peg end of the proximal phalanx. Trial seating is performed to be certain that the peg will seat securely. A Kirschner wire is usually utilized to insure stability during healing of the arthrodesis.

Following fixation in a corrected position, the extensor tendon is repaired utilizing 3-0 absorbable suture and the subcutaneous and skin layers are closed.

The peg in hole procedure has the advantage of providing more bone to bone contact and consistently heals more rapidly than the traditional end to end fusion. One of the major disadvantages with this procedure is shortening of the digit. Often this is an advantage. But in instances where previous surgery has shortened the toe further shortening may be undesirable.

There is always a possibility of dorsal cortical fracture of the peg which can create instability between the two bones. This complication has been largely eliminated by the use of a K-wire.

The peg in hole procedure is often combined with metatarsophalangeal joint soft tissue releases and extensor hood recession to correct all components of the deformity. Overall, results have been excellent and the procedure has been especially effective in treatment of the clawtoe deformity.

Aftercare: Postoperative bandaging and splinting are usually continued for 6 weeks until radiographic studies confirm solid bony healing. At this point, bandaging may be discontinued and if K-wires were utilized they may be removed. Following removal of the wires range of motion exercises for the metatarsophalangeal joints are started. Supportive bandaging is needed for several weeks until edema is well controlled.

Interphalangeal End to End Arthrodesis with K-Wire Fixation

Indications: End to end arthrodesis of the interphalangeal joint with K-wire fixation is indicated in either flexible or rigid clawtoe deformity. This procedure is commonly performed in conjunction with metatarsophalangeal joint release and extensor tendon recession. It is especially useful in the presence of severe metatarsophalangeal joint derangement and long term soft tissue adaptation. Arthrodesis of the interphalangeal joint provides a stable lever arm on which the long and short flexors can function to assist stability of the metatarsophalangeal joint. Shortening of the toe is considerably less than is the case in the peg in hole procedure. It is, however, essential that adequate bone be resected to remove deforming forces on the digit.

Procedure: Similar to the performance of the peg in hole arthrodesis the surgical approach is either a linear, transverse, or two semi-elliptical transverse incisions. Dissection is carried down to the deep fascia covering the extensor tendons. The tendon is divided in a Z-plasty fashion. All neurovascular structures are identified and preserved while the extensor tendon is freed from its attachments to the proximal phalanx proximally to the level of the metatarsophalangeal joint. The interphalangeal joint is then flexed and the collateral ligaments are divided. The head of the proximal phalanx is resected in a transverse fashion utilizing a power saw. Care is taken to assure that all soft tissue attachments are freed from the proposed arthrodesis site.

The cartilage at the base of the middle phalanx is resected utilizing a bone forceps or an oscillating saw. A K-wire is used to create a channel in the proximal phalanx followed by driving the K-wire distally through the middle and distal phalanges exiting at the distal aspect of the toe. Care is taken to assure dorsiflexion of the interphalangeal joint as the K-wire crosses distal interphalangeal joint. Next the K-wire is driven proximally holding the proposed arthrodesis site in the corrected position. Once the middle and proximal phalanges have been aligned in a correct position, attention is then drawn to the metatarsophalangeal joint. With the toe held in a corrected position or slight plantar flexion the K-wire is introduced across the metatarsophalangeal joint down the intramedullary canal of the metatarsal. Radiographs may be taken intraoperatively to assure proper alignment and internal fixation. The tip of the wire is bent to a right angle and K-wire caps are utilized to protect the K-wire (Fig. 9).

Following fusion of the proximal interphalangeal joint the flexibility of the digit is reduced with motion now occurring at the distal interphalangeal and metatarsophalangeal joints only. The decrease in range of motion in most patients is not a problem postoperatively and the overall results of realignment of the digit and stability of the metatarsophalangeal joints is beneficial.

In clawtoe deformity there is deformity of the metatarsophalangeal joint. It is, therefore, advantageous to fixate across the metatarsophalangeal joint. The K-wire usually is maintained for approximately 6 weeks.

Aftercare: Following arthrodesis of the interphalangeal joint with K-wire fixation the patient may ambulate in a Darby trauma shoe with a felt or cork insert from the heel to the web area. With this modification in the surgical shoe, the toes are allowed to float over the end of the insole of the shoe preventing any undue stress on the K-wire fixation of the digits. Ambulation is allowed as tolerated. It is essential that the K-wire be protected against any bending force as it crosses the metatarsophalangeal joint. If K-wires do not cross the metarsophalangeal joint and are limited to the toe, the metatarsaphalangeal joint may have free range of motion postoperatively. In this latter situation the raised insole is not needed in the surgical shoe.

Following K-wire removal, the patient may bathe the foot, however, it is essential that compressive bandaging, exercises, and local care be provided to control postoperative edema which persists for several weeks. It should be noted that bony healing is not usually solid at six weeks with the end-to-end arthrodesis. In most cases it is advantageous to use a digital splint or retainer to maintain alignment following K-wire removal for an additional 4-6 weeks.

The overall results of end to end arthrodesis of the interphalangeal joint with K-wire fixation have been very gratifying. The procedure is one of the most reliable for correction of fixed clawtoe deformity.

Fig. 9. Kirschner wire caps are used to protect the wire tip.

Summary

Clawtoe deformity is a complex deformity which requires a systematic approach by the surgeon in selecting the appropriate procedure depending on the type and degree of the deformity.

In the more severe deformities, flexible or fixed, arthrodesis of the proximal interphalangeal joints with K-wire fixation combined with metatarsophalangeal joint capsulotomy and extensor tendon recession provide the most desirable postoperative result. The use of tendon transfers or tenotomies in the treatment of contracted digital deformities and clawtoe deformities is extremely limited as presented in this paper.

The reader is referred to chapter 3 entitled "Lesser Ray Deformities" by A. Louis Jimenez, D.P.M., E. Dalton McGlamry, D.P.M., and Donald R. Green, D.P.M. in *Comprehensive Textbook of Foot Surgery,* vol 1. Williams & Wilkins, Baltimore, 1987, pp 57-113 for a detailed discussion on digital deformities, including the clawtoe deformity.

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