CHAPTER 1

THE SURGICAL APPROACH TO THE FLEXOR DIGITORUM LONGUS TENDON TRANSFER

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INTRODUCTION

Hammertoe surgery is commonly performed by podiatric physicians. McGlamry describes three major etiologies of hammertoe contractures: extensor substitution, flexor stabilization, and flexor substitution.[1] It is important to realize that complex deformities may be a combination of these types. In general, hammertoe deformities are a progressive deformity and this progression is fairly predictable. Although there are many conservative treatment options, as the deformity progresses, surgery is often indicated. For the reducible proximal interphalangeal joint contracture without metatarsophalangeal joint involvement, the surgical options are often arthrodesis or arthroplasty. When the deformity progresses and the surgeon faces the rigid proximal interphalangeal joint contracture with significant deformity at the metatarsophalangeal joint, the options are not as straightforward. In addition, deformities that combine sagittal plane deformity with transverse plane deformity through attenuation or rupture of the plantar plate can be a surgical challenge. The sequential release for the reduction of hammertoe deformities has been well described.[1] The transfer of the flexor digitorum longus tendon is essentially the final stage in the sequential reduction of complex hammertoe deformities.

LITERATURE REVIEW

For flexible and rigid hammertoe deformities many tendon transfer procedures have been described.[2-13] The transfer of the flexor digitorum longus tendon dates back to the early 1900s. Trethowan[2] in 1925 makes reference to FDL transfers for the correction of clawed toes. Taylor[3] in 1951 described a transfer of the long and short flexor tendons to the extensor expansion. This procedure is known as the Girdlestone-Taylor procedure as it was initially performed by Girdlestone[13] years earlier. Forester-Brown[4] in 1938 described a looping of the extensor tendon around the metatarsal neck for the treatment of claw toes. Transfer of the FDB tendon with resection of the base of the proximal phalanx was noted by McCain[5] in 1958. Sgarlato[6] in 1970 describes a similar procedure with the FDL tendon.

There have been several different techniques described for the FDL tendon transfer. Marcinko et al.[7] in 1984 describes this procedure with tenotomy of the flexor brevis and transfer of the long flexor around the base of the proximal phalanx through a longitudinal interdigital skin incision. Kuwada[8] in 1988 used a drill hole in the proximal phalanx to secure the FDL tendon after transfer.

Burleigh et al.[9] in 1993 described a two incisional technique for reducible hammertoe deformities. A dorsal semi-elliptical incision is performed longitudinally over the proximal interphalangeal joint and a second V-shaped plantar incision is performed. The FDL tendon is harvested and then transferred around the neck of the proximal phalanx. For flexible deformities, an arthroplasty was not performed. For rigid deformities, arthroplasties were performed and the plantar V-Y incision was deleted. Results were rated as being good to excellent by 78% of the patients.

Also in 1993, Thompson[11] described the flexor tendon transfer for instability at the metatarsophalangeal joint. The surgical technique included release of the metatarsophalangeal joint capsule followed by transfer of the FDL tendon to the "dorsal structures" overlying the proximal phalanx. It is interesting to note that "in a few cases the slips (of the FDL tendon) were tied to themselves to add strength to the repair." The authors reported that all patients had substantial pain relief.

The FDL tendon transfer for metatarsophalangeal joint instability has recently been compared to primary repair of the plantar plate by Ford et al.[12] in 1998. Their results show that there was no significant difference between the two repair sequences. Regardless of the techniques used for the FDL transfer, the most common postoperative concerns were stiffness, residual discomfort, and floating toe.[10,11]

CLINICAL EXAM

The clinical exam for the evaluation of digital deformities begins with a comprehensive biomechanical exam of the entire foot. Digital deformities may be a consequence of more proximal foot pathology. For example, an equinus deformity may induce extensor substitution hammertoes. This occurs as the extensors compensate for a lack of dorsiflexion during the swing phase of gait to allow the digits to clear the ground. Another example is in a pes valgus deformity with excessive subtalar joint pronation. A loss of the rigid beam effect in the digits causes instability. The flexors fire early to stabilize the digit against the weight-bearing surface, causing digital contractures.

Once the biomechanical pathology is identified, the clinical exam can be focused at the digital level. The exam begins with the metatarsophalangeal joint and progresses distally to the proximal interphalangeal joint, and then on to the distal interphalangeal joint. Each joint should be evaluated and assessed based on its ability to be reduced to an anatomic position. The joint may be reducible, semi-reducible, or non-reducible. Another way to describe this motion is flexible, semi-rigid, or rigid. This assessment should be made with the foot in a neutral position. It is important to evaluate the digit in the sagittal, transverse, and frontal plane. Figure 1 shows a hammertoe of the second digit with deformity in all three planes. The metatarsophalangeal joint is subluxed medially and contracted dorsally. The proximal interphalangeal joint is contracted in a plantarflexed position. Also note that the digit has a varus rotation. The Kelikian push-up test may be performed. Other similar tests include the vertical stress test and the Lachman test. Thompson and Hamilton describe the vertical stress test as a straight dorsal subluxation of the proximal phalanx on the metatarsal head. This is performed with the metatarsophalangeal joint in approximately 25 degrees of dorsiflexion. The ability to dislocate the joint dorsally is graded from zero to three, with zero representing no instability and three representing complete dislocation. The Lachman test is similar, only without the grading system.

Standard plain film radiographs can be very useful. (Fig. 2) The dorsal-plantar projection is very

Figure 1. Severe 2nd digit hammertoe deformity with contracture at the metatarsophalangeal joint and proximal interphalangeal joint. Note the varus rotation with adduction.

Figure 2A. DP projection of dislocated 2nd metatarsophalangeal joint.

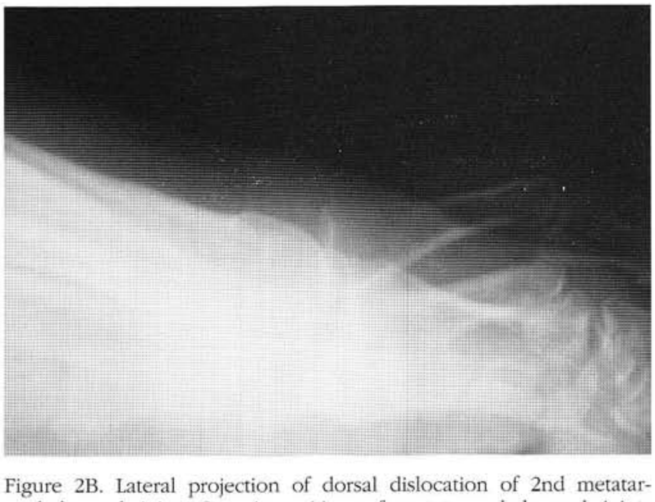

Figure 2B. Lateral projection of dorsal dislocation of 2nd metatarsophalangeal joint. Superimposition of metatarsophalangeal joints makes evaluation difficult.

helpful in evaluating both transverse and sagittal plane deformity. Transverse subluxation and/or dislocation will be obvious in more advanced deformities. Subtle subluxations may be more difficult to assess. Sagittal plane deformity may be easily identified with the "gun-barrel" sign. The gun-barrel sign is the outline of the phalangeal cortical shell seen with the lucent medullary canal, as the interphalangeal joint is plantarflexed. Lateral radiographs may give an excellent view of the proximal and/or distal interphalangeal joints in more severe deformities. However, the metatarsophalangeal joints of the lesser metatarsals may have too much overlap to achieve a good assessment. Evaluation of dorsal dislocations at the metatarsophalangeal joint are best performed with the tests described previously.

INDICATIONS

After the comprehensive clinical exam, the question still remains, when is the flexor tendon transfer indicated? There may not be any absolute indications as this procedure has been performed for several different types of hammertoe deformities. Burleigh et al.[9] performed the flexor tendon transfer for flexible and rigid contracture at the proximal interphalangeal joint with or without arthroplasty. Ford et al. used the flexor tendon transfer for metatarsophalangeal joint instability after plantar plate sectioning. Thompson[11] also performed this procedure for instability at the metatarsophalangeal joint.

The authors feel that the decision to perform the flexor tendon transfer should be made as an intra-operative decision, rather than preoperatively. The flexor tendon transfer is the final stage in the sequential reduction of metatarsophalangeal joint and proximal interphalangeal joint deformity. It is only after the resection of the proximal interphalangeal joint, release of the extensor hood fibers, proximal z-plasty of the extensor tendon complex, and metatarsophalangeal joint capsular release that any remaining residual deformity can be evaluated. It is at that time that the decision for flexor tendon transfer can be made. At this critical stage, if anatomic reduction of the digit cannot be performed and there is still a tendency for the proximal phalanx to drift dorsally on the metatarsal head, the flexor tendon transfer is performed. The flexor tendon will be split and drawn over the proximal phalanx and sutured on to itself. The result of the transfer is a two-fold biomechanical advantage. First the flexor will actively plantarflex the proximal phalanx against the weight-bearing surface. Second, the flexor tendon will passively resist dorsal dislocation. It should also be noted that active stabilization of the digit to the ground will help to resist transverse plane forces.

SURGICAL TECHNIQUE

Incision Placement

The authors use a single dorsal incisional approach for flexor tendon transfer. The incision is made from the neck of the metatarsal head extending distally across the metatarsophalangeal joint and ending at the mid-portion of the middle phalanx. The incision is curved slightly over the metatarsophalangeal joint and is placed dorsally to prevent laceration of the four neurovascular bundles.(Fig. 3A)

Figure 3A. Dorsal linear incisional approach avoids laceration of neurovascular structures.

Subcutaneous Dissection

To maintain appropriate hemostasis, anatomic dissection is critical. Although a dorsal incision will prevent entrance into the major neurovascular structures, often there are crossing tributaries in the subcutaneous tissues. The vessels are isolated, clamped, and either ligated or coagulated with electrocautery. There seems to be a fairly consistent vein crossing at the level of the metatarsophalangeal joint. The goal of the subcutaneous dissection is to achieve hemostasis and expose the deep fascia. The deep fascia at the proximal interphalangeal joint is the tendon sheath over the long extensor tendon and joint capsule.(Fig. 3B)

Capsular Dissection

Disarticulation of the proximal interphalangeal joint is accomplished initially by plantarflexing the joint. Plantarflexion of the joint pushes the head of the proximal phalanx against the dorsal capsule and places the collateral ligaments in a vertical orientation. The collateral ligaments are easily transected. The articular surface of the head of the proximal phalanx does not have any capsular attachments. Transverse sectioning of the long extensor tendon and dorsal joint capsule will give excellent exposure to the head of the proximal phalanx. Sectioning of the collateral ligaments at the inferior aspect of the head of the proximal phalanx will allow the ligaments to be preserved. These ligaments are dissected off of the dorsal epicondyle of the proximal phalanx head. This flap of medial and lateral collateral ligament should be continuous, with the transverse capsular incision creating a soft tissue hood over the head of the proximal phalanx. (Fig. 3C)

Extensor Hood Release

The subcutaneous tissues should now be reflected off of the metatarsophalangeal joint capsule, exposing the extensor digitorum longus and the extensor digitorum brevis tendons. The extensor hood fibers are released on the medial and lateral aspects of the combined extensor apparatus. The hood release is only performed around the metatarsophalangeal joint. The extensor tendon complex should still be entirely intact at the level of the middle one-third of the proximal phalanx.

Proximal Z- Plasty

The z-plasty, or lengthening of the extensor complex is performed by identifying the slips of the extensor digitorum longus tendon and the extensor digitorum brevis tendons. A longitudinal incision is made from distal to proximal between the two tendons. The long extensor tendon is transected distally at the point where it joins the extensor brevis tendon. The long extensor tendon remains long. The extensor brevis tendon is transected proximally, at a point that is proximal to the metatarsophalangeal joint. The short extensor tendon remains short. Each tendon is retracted proximally and distally respectively, exposing the metatarsophalangeal joint capsule.(Figs. 3D-F)

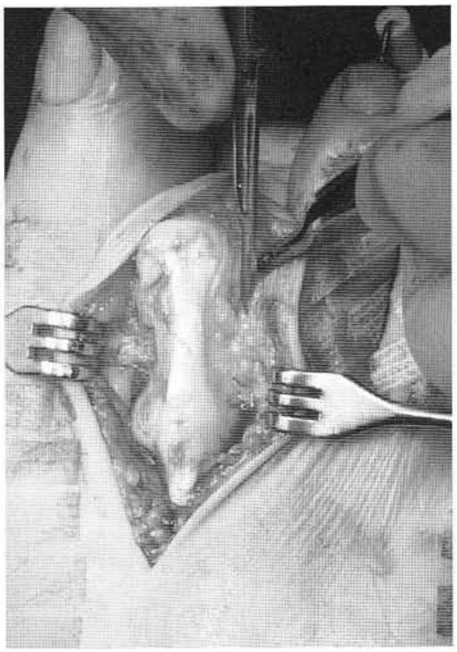

Figure 3B. Reflection of the subcutaneous tissues away from the deep fascia with exposure of the extensor digitorum longus tendon over the proximal phalanx.

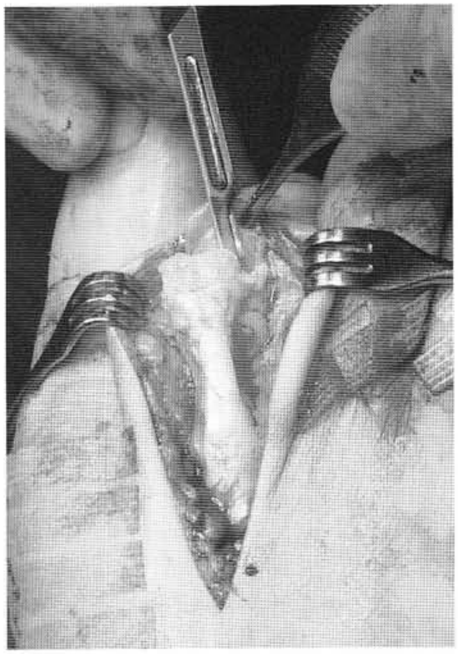

Figure 3C. Proximal interphalangeal joint dissection with preservation of the medial and lateral collateral ligaments.

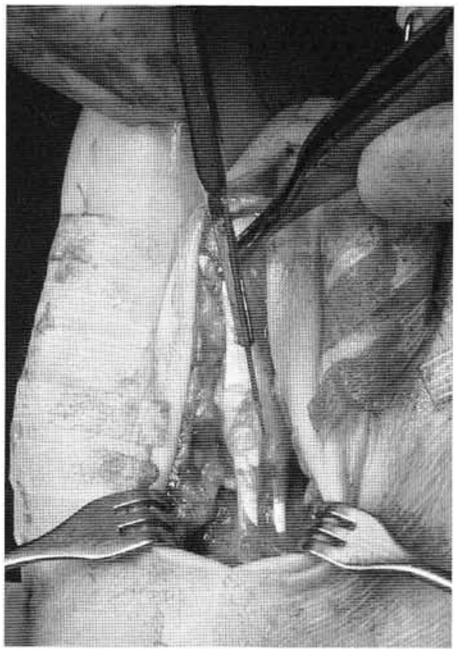

Figure 3D. Longitudinal incision between the extensor digitorum longus tendon medially and the extensor digitorum brevis tendon laterally.

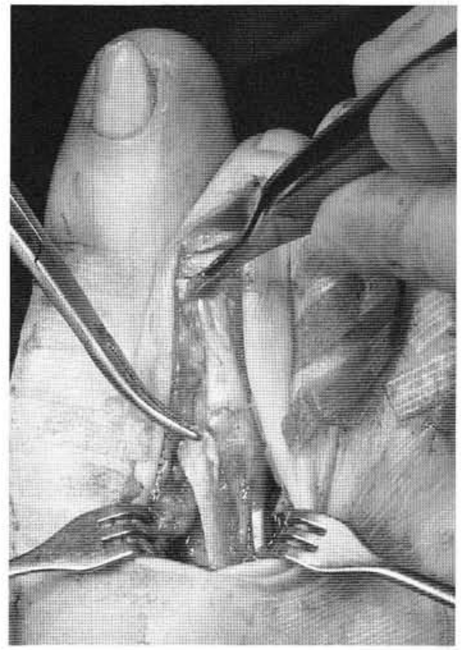

Figure 3E. Transection of the extensor digitorum longus tendon distally.

Metatarsophalangeal Joint Release

Distal tension is placed on the proximal phalanx, as the proximal phalanx is dorsiflexed and plantarflexed. This will show the "puckering" of the metatarsophalangeal joint capsule. Once the capsule is identified, distal traction is placed on the phalanx creating tension on the metatarsophalangeal joint capsule. Risk of laceration into the cartilage of the metatarsal head is reduced. A dorsal, medial, and lateral capsulotomy is performed. (Figs. 3G-H)

Resection of the Proximal Interphalangeal Joint

The proximal interphalangeal joint is prepared for arthrodesis by resection of the head of the proximal phalanx and resection of the cartilage off of the base of the middle phalanx. Hand instruments are used to decrease the risk of thermal necrosis. In addition, hand instrumentation allows for a roughened fusion surface, which gives a greater surface area and allows for interdigitation between the two osseous surfaces. (Fig. 3I)

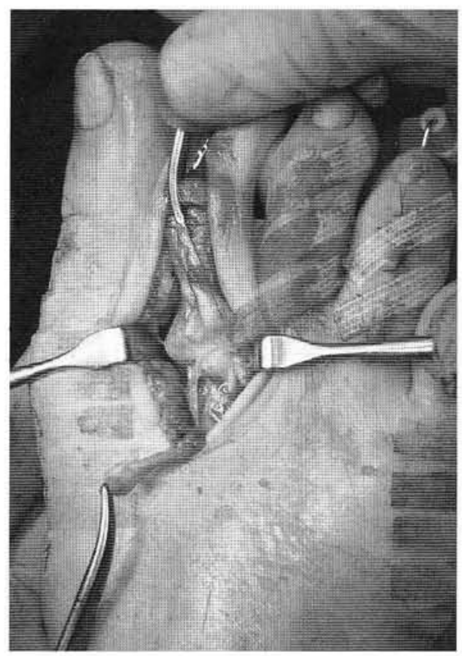

Figure 3F. Transection of the extensor digitorum brevis tendon with exposure of the metatarsophalangeal joint capsule.

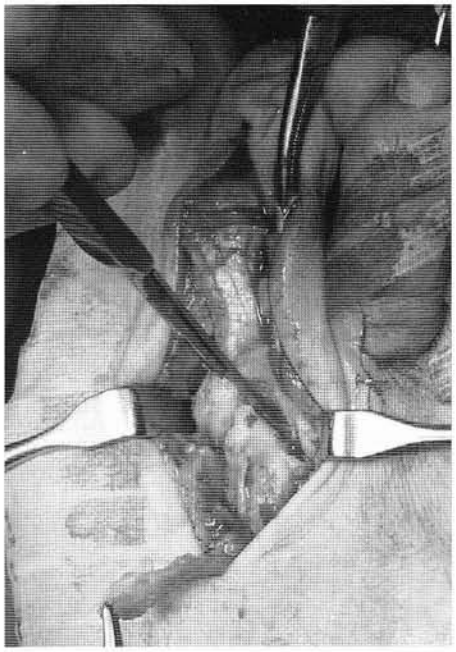

Figure 3G. Metatarsophalangeal joint capsulotomy.

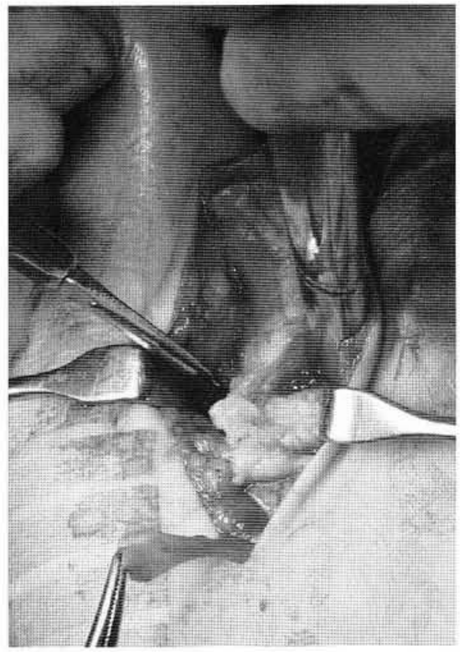

Figure 3H. A McGlamry elevator may be used to release plantar adhesions.

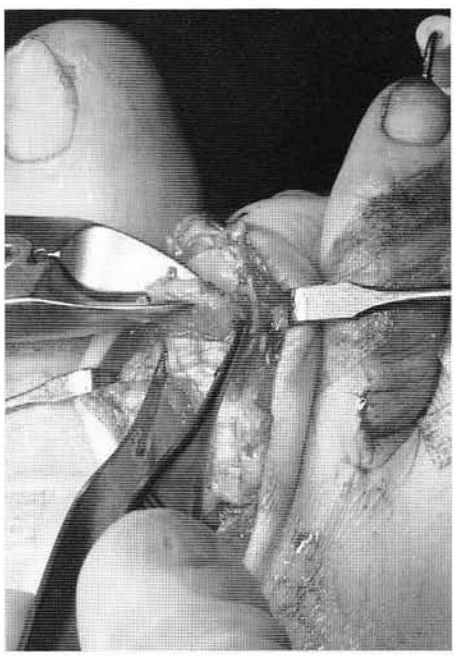

Figure 3I. Hand instrumentation is preferred for resection of the proximal interphalangeal joint.

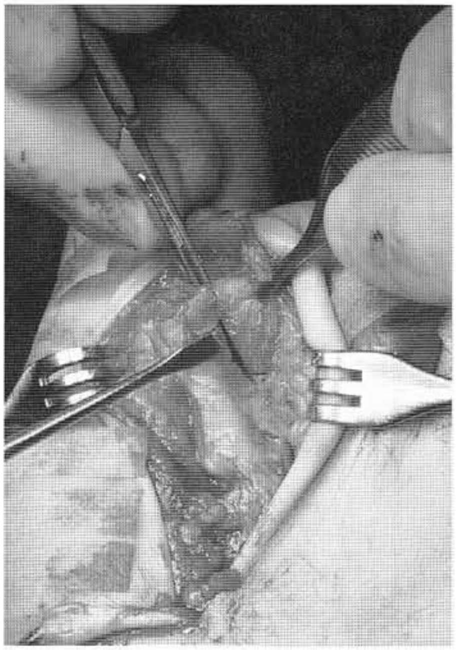

Figure 3J-L. Inferior fibers of the extensor sling are incised to release the flexor digitorum longus and brevis from the proximal phalanx.

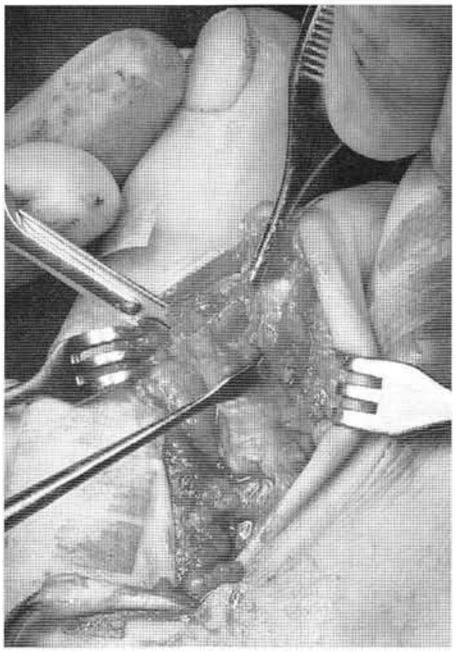

Figure 3K.

Harvesting of the Flexor Digitorum Longus Tendon

Attention is now directed to the inferior lateral and medial surfaces of the proximal phalanx. An incision is made through the deep fascial attachments along the inferior surface of the proximal phalanx medially and laterally. A Freer/elevator is then passed along the inferior surface of the proximal phalanx along the superior surface of the combined flexor tendon complex. Care must be taken to preserve the periosteum. At the level of the proximal interphalangeal joint, the combined flexor digitorum longus and brevis tendons are identified. The slip of the long flexor must be isolated from this complex. Keep in mind that the short flexor is split at this level. The medial and lateral slips of the short flexor are on the outside of the long flexor. The short flexor inserts into the base of the middle phalanx. Confirmation that the long flexor has been isolated is performed by pulling on the tendon and observing plantarflexion of the distal phalanx without plantarflexion of the middle phalanx. (Fig. 3J-L)

Figure 3L.

Transfer of the Flexor Digitorum Longus Tendon

The flexor digitorum longus tendon is split longitudinally in its central aspect at the level of the proximal interphalangeal joint. The tendon has not been transected. It is easier to split the tendon prior to transection while there is still resting tension on the tendon. A hemostat is then used to grasp each slip of the tendon. An absorbable suture is tagged to the distal portion of the long and short flexors. The tendon complex is transected at the base of the middle phalanx. The medial and lateral slips of the long flexor tendon are then directed proximally. Each slip is placed over the shaft of the proximal phalanx. Prior to suturing the tendon ends, the proximal interphalangeal joint arthrodesis is performed. A smooth K-wire is used to secure the arthrodesis site. The slips of the flexor tendon are now sutured together using non-absorbable suture over the top of the proximal phalanx. The term "physiologic tension" is often used at this stage. Physiologic tension is a variable and non-reproducible measurement and therefore will not be discussed. It ultimately becomes a judgment call as to the amount of tension to place on the tendon. The greater the tension, the greater the correction at the cost of potential increased postoperative stiffness. If a K-wire is to be driven across the metatarsophalangeal joint, it should be driven first across the proximal interphalangeal joint before the transfer. The tendon is sutured onto itself and the K-wire is advanced across the metatarsophalangeal joint. (Figs. 3M-R)

Closure

The extensor apparatus over the metatarsophalangeal joint is re-approximated with absorbable suture. Attention is then directed to the proximal interphalangeal joint where the previously described extensor/collateral hood complex is re-approximated. The extensor tendon is sutured and the medial and lateral collateral ligaments are individually repaired at this time. The subcutaneous layer is sewn together in a running fashion with absorbable suture. The procedure is concluded with a running subcuticular skin closure with absorbable suture.

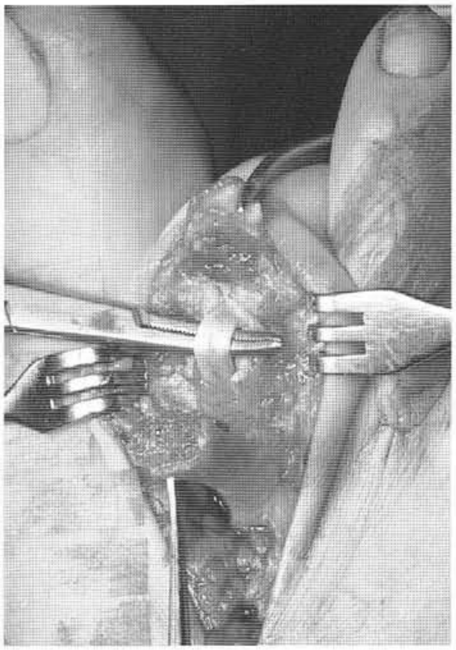

Figure 3M. Isolation of the flexor digitorum longus tendon.

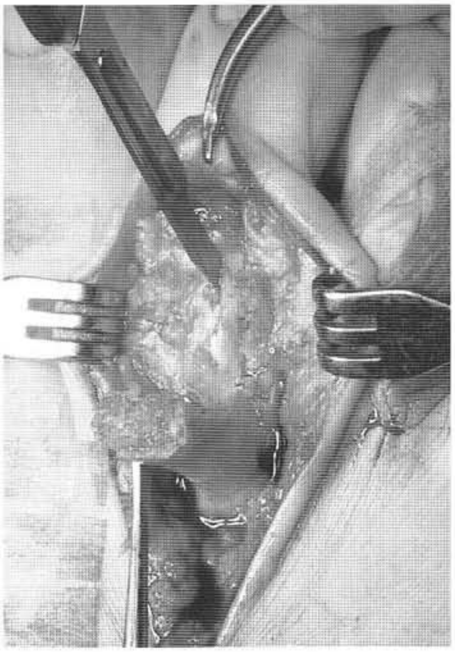

Figure 3N. Longitudinal incision through flexor digitorum longus tendon.

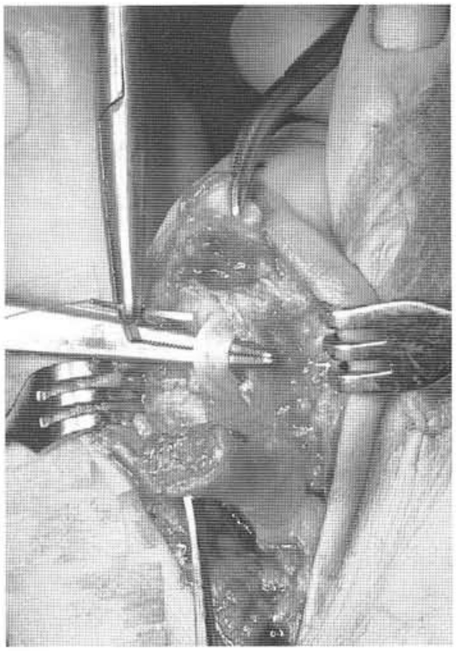

Figure 3O. The flexor digitorum longus is tagged to the flexor digitorum brevis for added distal stability.

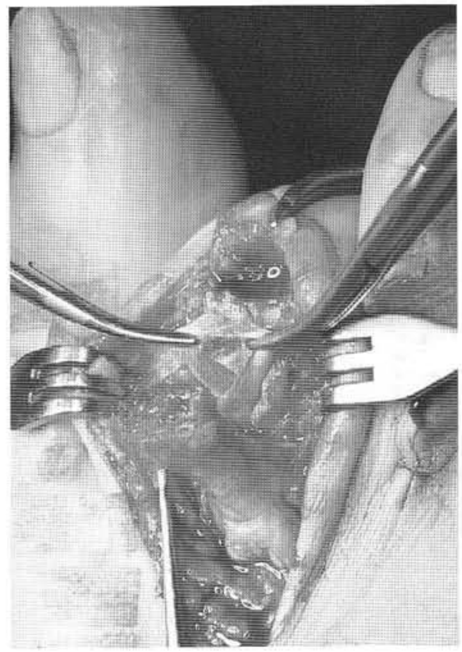

Figure 3P. The medial and lateral slips of the long flexor are separated.

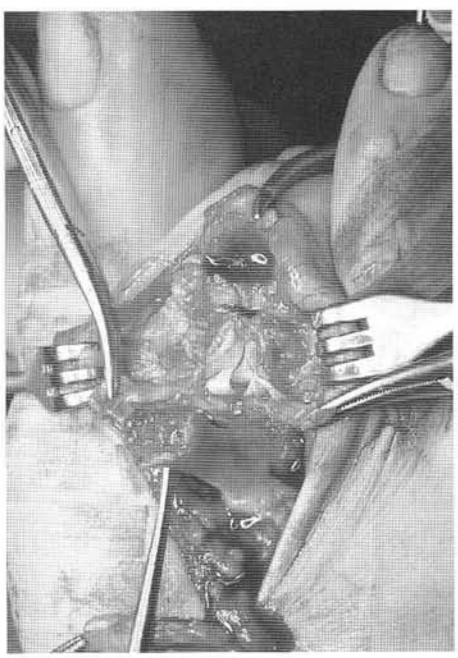

Figure 3Q. The long flexor is transected distally. The medial and lateral slips of the flexor digitorum longus and brevis tendons are seen. The brevis tendon is reinforced distally with the remaining distal tag of the long flexor.

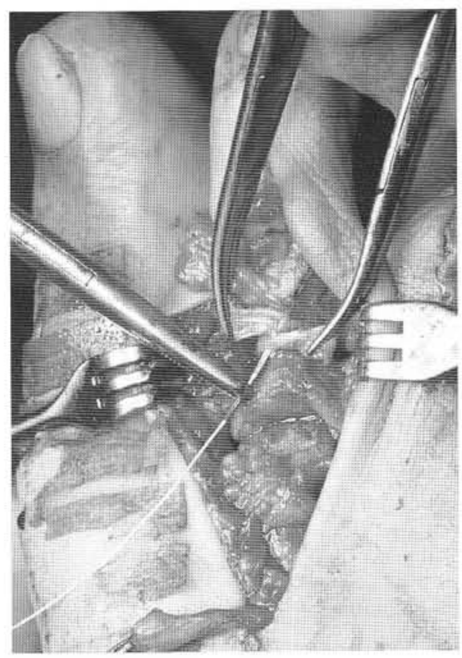

Figure 3R. The flexor tendon is transferred over the top of the proximal phalanx and sutured back onto itself.