CHAPTER 1

SURGICAL DECISION MAKING IN HAMMERTOE DEFORMITY

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Too often, the surgical choice in toe surgery is arthroplasty. Regardless of etiology, foot type, level, or flexibility of deformity, excision of the phalangeal head is the preferred procedure. Although this usually provides symptomatic relief, recurrence is a problem. Beyond the clinical aspects of improperly chosen procedures, we belittle our profession and minimize our educational accomplishments by reducing all hammertoe surgery to "arthroplasty." The metatarsophalangeal joint (MPJ) and digit are a complex array of bone and soft tissue which serve as anchors for the intrinsic and extrinsic musculature of the foot and leg. The anatomic and functional intricacies will direct the surgeon to the appropriate procedure(s) and a more refined technique.

Any discussion of digital deformity and correction must include the contribution of the metatarsal, specifically the MPJ. The MPJ and interphalangeal joint (IPJ) are stabilized by collateral ligaments running obliquely on either side of the joint. Dorsally, only a thin capsule exists. Plantar stability is provided by the flexor plate which is a thick fibro-cartilaginous structure that prevents dorsal subluxation, particularly of the MPJ. The short flexor splits into two slips that attach to the middle phalanx. The long flexor passes through the split in this tendon and then inserts into the distal phalanx. The long flexor, when the toe is unopposed by a weight-bearing surface will flex the MPJ and IPJ (Fig. 1). In a weight-bearing situation, since the toe cannot plantarflex through the supporting surface, the long flexor tendon will pull the distal phalanx proximally, buckling the toe. In a weight-bearing situation, use of the long flexor alone will produce a claw toe, while pull of the long and short flexors will recreate a true hammertoe (Figs. 2, 3).

Dorsally, the long extensor tendon has an anatomic insertion which differs from its functional attachment. The extensor digitorum longus (EDL) trifurcates over the toe with the central expansion attaching to the middle phalanx, and the two lateral slips attaching to the distal phalanx. The EDL,

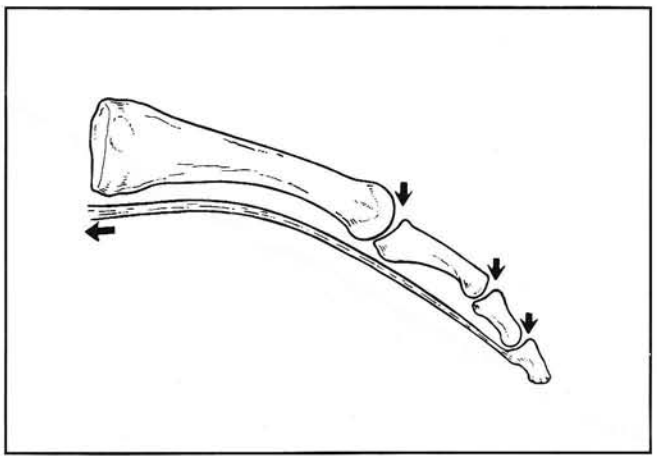

Figure 1. Unopposed pull of FDL flexes MPJ and IPJs.

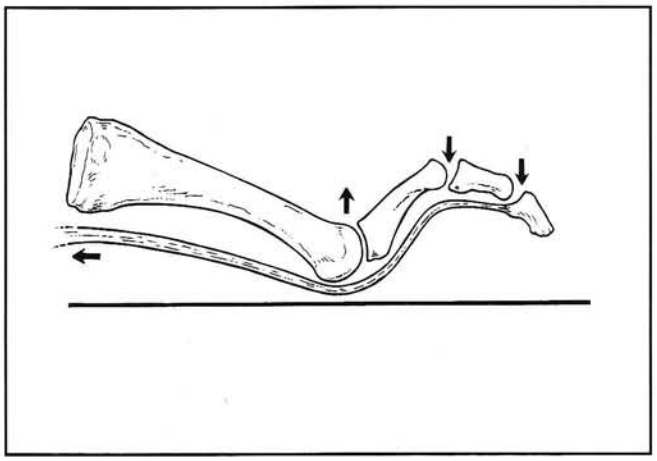

Figure 2. On a supporting surface, FDL will create a claw toe.

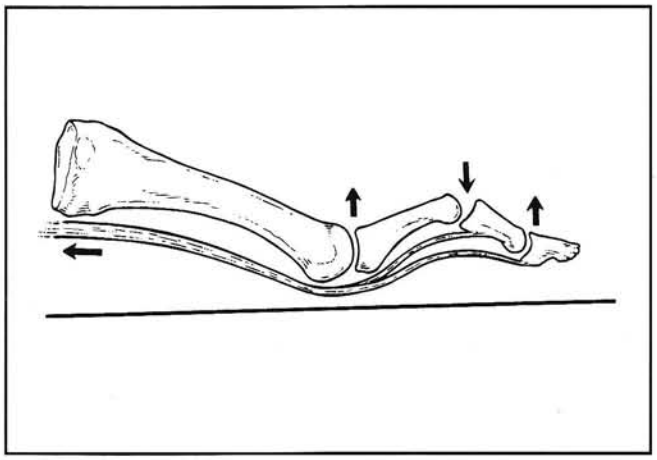

Figure 3. On a supporting surface, FDL and FDB will create a hammertoe.

however is an extremely weak dorsiflexor of the IPJ, but a strong extensor of the MPJ. This effect is created by the extensor hood apparatus. The hood is an expansion of the deep fascia of the long extensor. Its dense fibers fan medial and lateral around the MPJ, and proximal phalanx attaching primarily to the flexor plate and plantar aspect of the base of the proximal phalanx (Fig. 4). This converts nearly the entire pull of the long extensor to the MPJ. Contracture of the hood will now maintain the dorsal subluxation of the digit. Proximal pull of the EDL results in a dorsiflexion at the MPJ, but plantar flexion at the IPJ (Fig. 5). Since there is so little extensor force at the distal interphalangeal joint (DIJ) and proximal interphalangeal joint (PIJ), the passive pull of the long flexor as the toe extends at the MPJ will cause flexion at the IPJs. Should the long flexor be transected, the MPJ and IPJs will now be extended (Fig. 6).

The common factor in all digital deformity whether caused by flexor or extensor tendon, is dorsiflexion at the MPJ. If stability of the MPJ can be maintained, digital deformity will not occur. During the normal gait cycle, this stability is provided through the intrinsic musculature, by the interossei and the short flexor in the stance phase of gait, and by the lumbricales during the swing phase of gait. The goal of surgery, therefore, is to provide or restore stability to the MPJ. If the MPJ is not rebalanced, the digital correction will not be maintained.

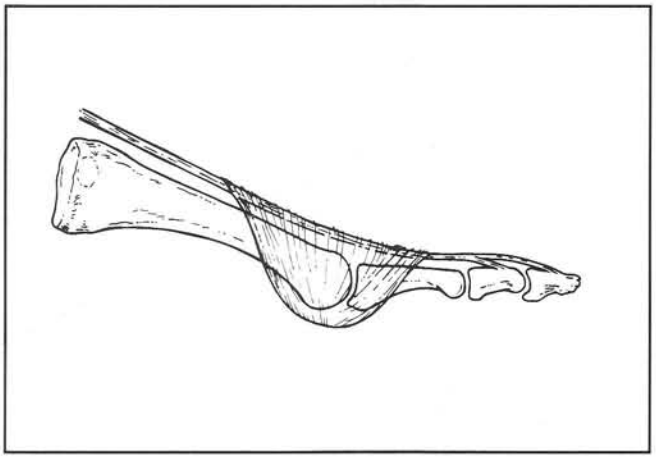

Figure 4. Extensor hood apparatus converts the power of the long extensor to the MPJ.

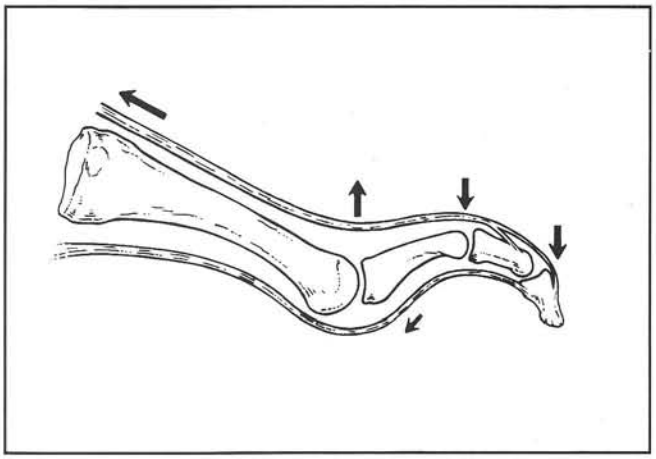

Figure 5. Active contracture of the EDL will result in IPJ flexion due to the passive pull of FDL.

PATHOMECHANICS

Digits deform for a variety of reasons, the vast majority are mechanical in nature. Etiology of digital deformity can be divided into broad categories of intrinsic loss/weakness, extensor substitution, and flexor stabilization.

Intrinsic muscle weakness is quite common and most often associated with a flatfoot deformity. Since the intrinsic muscles are mild supinators of the midtarsal joint, they will contract with more intensity, for a longer period of time attempting to stabilize the pronating foot. This eventually leads to fatigue, cramping, pain, and loss of MPJ stability. Other conditions resulting in loss of intrinsic function are neurologic disorders such as Charcot-Marie-Tooth disease, or chronic tarsal tunnel syndrome. Significant forefoot deformity as seen in cavus foot may alter the tendon pull by changing

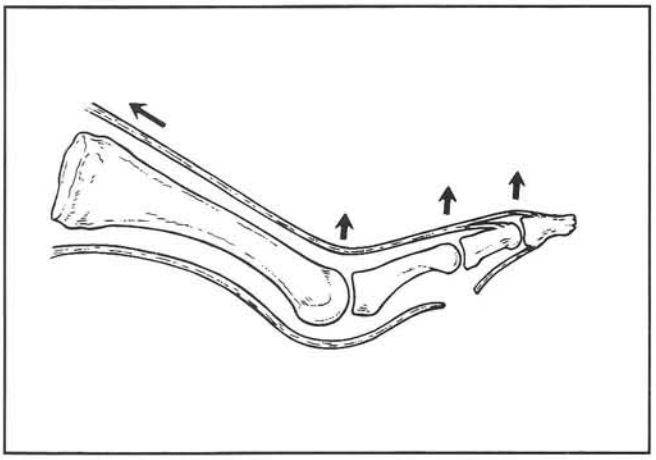

Figure 6. Active contracture of EDL without influence of FDL results in extension of MPJ, IPJs.

the location of the MPJ axis, also resulting in decreased effectiveness of the intrinsic muscles.

Flexor stabilization is most commonly seen in a pronated foot as well. The long flexor tendons are supinators of the subtalar joint and midtarsal joint. As the foot pronates, these muscles fire earlier in the gait cycle and continue to contract into the swing phase. Initially, they will overpower the intrinsics and develop a classic hammertoe deformity. As the intrinsics weaken and the short flexor is lost, the hammertoe will convert into a claw toe. Weakness of the triceps surae resulting from surgery or injury may also cause the long flexors to over-compensate.

In the clinical setting, this condition is quite easy to recognize. In the stance phase of gait, as the forefoot is loaded, marked gripping of all toes is noted. A varus rotation to the fifth toe, and sometimes the fourth toe is present as well.

Extensor substitution is a distinct entity appreciated in both the non-weight bearing and gait examination. On the examination table all the digits are generally subluxed at the MPJ and the long extensor tendons are bowstrung. During gait, the extensor digitorum longus begins firing earlier, during the late part of mid-stance, throughout the swing phase, and continues through heel contact. This typically produces clawing of all of the lesser digits.

Extension substitution is most commonly seen in a cavus foot. In the cavus foot the forefoot is plantarflexed on the rearfoot. As the heel lifts off the supporting surface, the forefoot is now below the level of the rearfoot. To prevent the individual from tripping over the plantar declinated metatarsals, the extensor must fire earlier and more forcefully to provide ground clearance. As the foot again enters the stance phase, the extensors must continue contracting so the heel contacts the ground before the forefoot.

Another common condition resulting in extensor substitution is equinus. Ten degrees of dorsiflexion of the leg over the foot at midstance is required for normal ambulation. When the Achilles is contracted, the EDL attempts to assist the individual who is unable to achieve sufficient ankle dorsiflexion by working from insertion to origin. The long extensor tendons are now attempting to pull the leg forward over the foot. As a result, the MPJs are pulled into hyperextension, thus initiating hammertoe deformity.

The goals of surgical correction should be to correct the deformity and remove the deforming forces. Several common digital surgical procedures will be reviewed and the biomechanical effects analyzed.

SURGICAL MANAGEMENT

Arthroplasty

Resection of the head of the proximal phalanx provides symptomatic relief of dorsal hyperkeratosis, regardless of origin. In flexor hammertoes, removal of the bone will shorten the distance from the origin to insertion of the FDL, thereby placing slack and subsequently weakening the tendon. In many instances, this will be sufficient to remove the deforming force and provide adequate long-term relief. This may produce adjacent flexor loading which will be discussed later.

Extensor hammertoes are relatively unaffected by arthroplasty, other than removal of the dorsal prominence. Since the bone excised is distal to the insertion of the extensor hood and MPJ, a contracture present before arthroplasty will be present afterwards as well. Since the proximal phalanx remains dorsally subluxed, the remaining bone may still be prominent. This often necessitates removing a larger amount of bone than one might anticipate. There is little to no extensor loading with arthroplasty.

Theoretically, arthroplasty is only indicated in a non-reducible rigid contracture, because flexible deformities should be corrected by soft tissue procedures alone. However,from a practical view point it is used both in rigid and flexible hammertoes.

Arthrodesis

Fusion of the PIJ is indicated when the deforming force cannot be controlled either biomechanically or surgically. It is most effective in cases of muscle weakness, spasticity or significant deformity. The degree of flexibility of the toe is not a factor in choosing this procedure. With arthroplasty,the shortening of the digit will have little to no effect on the long extensor, only the flexor. Typically, an end-to-end arthrodesis will provide less shortening, and may be more appropriate for extensor hammertoes. A peg-in-hole arthrodesis will allow significantly more shortening, and may be more

suitable for flexor hammertoes as a means of eliminating the deforming force. Arthrodesis is effective in both extensor and flexor hammertoes. Stiffening the PIJ converts the long and short flexors from the role of deformers of the IPJ to plantar stabilizers of the MPJ. The passive pull of the tendons is now sufficient to prevent swing phase extension. Now that there is less dorsiflexory movement at the MPJ, the EDL becomes a more efficient dorsiflexor of the ankle.

Extensor Tenotomy and/or Capsulotomy

Extensor tenotomy is indicated for the treatment of flexible hammertoes, of extensor etiology, or as adjunct to osseous surgery. For example, an arthroplasty in an extensor hammertoe requires a tenotomy to reduce any contracture at the MPJ, and to remove the deforming force providing the contracture. Tenotomy will cause loading to the adjacent tendons. The effectiveness of the procedure directly relates to the location and status of the hood apparatus. If the hood is contracted, a tenotomy will be effective only if it is performed proximal to the hood. A tenotomy performed over the MPJ, at the hood's mid-portion, will not effectively relocate the toe because the proximal portion of the hood can still deform the MPJ. A tenotomy should ideally be performed 1.5 cm to 2 cm proximal to the MPJ. Tendon regrowth should be anticipated (Fig. 7).

In many instances, a tenotomy alone will not release the joint. If the procedure is to be performed percutaneously a capsulotomy is often required. In order to cut all hood fibers, an effective capsular release needs to be cut down the medial and lateral aspect of the joint as well as the dorsal surface. In open cases, the hood fibers can be severed independently of the capsule.

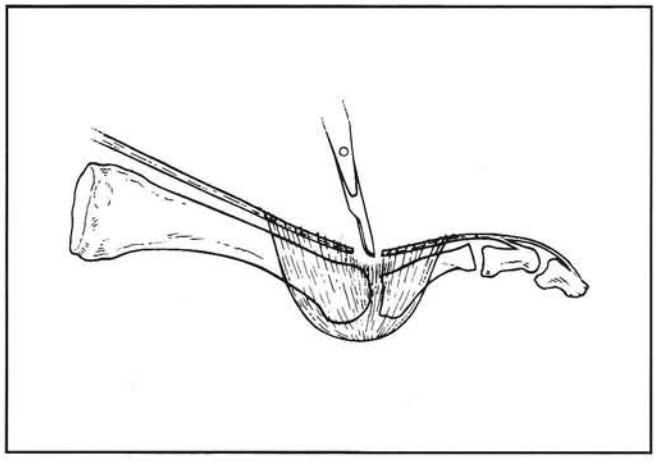

Figure 7. Tenotomy over the MPJ will not fully release the joint due to continuity of the hood.

Flexor Tenotomy

Flexor tenotomy is indicated in flexible hammertoe, and mallet toe deformity of flexor etiology. It may also be effective in semi-rigid deformity if a plantar capsulotomy is performed as well. It is only indicated for flexor hammertoes. If the flexor toe deformity is a mallet toe or claw toe, this indicates the etiology is a contracted FDL and a tenotomy is performed at the DIJ. A true hammertoe-indicated deformity involving both the FDL and FDB, hints a tenotomy should be performed at the PIJ or proximal to insure severance of both tendons. Regrowth is not as predictable, due to the avascular sheath the flexor tendons are encased in. Flexor loading is a potential problem. Loading occurs because the long flexors, as well as the extensors each arise from a common origin, then split into four slips. Tension is then divided among these four slips. Cutting one or more will transfer forces to the adjacent remaining tendons.

Flexor Tendon Transfer

Flexor tendon transfer can be used for both extensor and flexor hammertoes, as well as flexible or rigid hammertoes. Flexor tendon transfer converts the FDL to a plantar flexor and proximal stabilizer of the MPJ. This eliminates the long flexor as a deforming force, and negates the ability of the short flexor to cause deformity. The increased passive tension on the MPJ will also stabilize the joint during swing phase. Because the tendon is still intact, no flexor loading occurs. If the procedure is combined with an arthroplasty, there is total loss of osseous and soft tissue integrity leading to loose, floppy toes. It is plausible that over-flexion of the MPJ may occur with transfer but this seems to be only an academic concern.

The etiology and anatomy of digital deformity is complex, yet understandable. Identifying the etiology of digital pathology and selecting an appropriate procedure or procedures to eliminate the specific etiology will provide satisfactory long-lasting correction.