

Essential Insights On Tendon Transfers For Digital Dysfunction

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Author(s): Lawrence DiDomenico, DPM, FACFAS

While tendon transfers have traditionally been reserved for flexible digital deformities, these procedures may be effective for semi-rigid and sometimes rigid deformities. Accordingly, this author discusses the initial assessment, reviews potential biomechanical etiologies and offers a step-by-step guide to the modified Girdlestone-Taylor procedure and the modified Hibbs procedure.

Digital deformities are among the most frequent deformities that foot and ankle surgeons see. Toe deformities are common but not always symptomatic. Once symptomatic, the digital deformities may require surgical correction if one has attempted non-operative care and failed.

When it comes to restoration of these deformities, many surgical techniques have been discussed in the literature. In my opinion, arthroplasty and arthrodesis techniques are currently the more commonly utilized procedures for the repair of digital deformities. However, complications such as shortened toes, rotated toes, deviated toes, contracted toes and “sausage toes” have occurred repeatedly following arthroplasties and arthrodesis procedures.

In my experience, these arthroplasties and arthrodesis do not provide as predictable as an outcome and are fraught with more complications than tendon transfers for digital deformities.

How To Differentiate Among Digital Deformities

Over the years, there has been a relaxed depiction among foot and ankle surgeons when it comes to digital deformities. Often surgeons refer to a deformed digit as a “hammertoe,” which can lead to misunderstanding. It is imperative that one uses the appropriate terminology in order to help ensure the proper surgical groundwork.

A mallet toe presents with a flexion contracture at the distal interphalangeal joint. This toe has a normal anatomical position of the proximal interphalangeal joint as well as the metatarsophalangeal joint (MPJ).¹

A hammertoe consists of an extended or hyperextended distal interphalangeal joint, a flexion contracture at the proximal interphalangeal joint and mild hyperextension of the MPJ.¹



A claw toe entails a flexion contracture at the distal interphalangeal joint and proximal interphalangeal joint along with extension at the metatarsophalangeal joint.¹

A deviated toe results from synovitis, a sequela of MPJ instability, which results in a varus or valgus alignment.¹ The progressive deviated toe with instability can lead to subluxation and dislocations with a hammertoe deformity.²

A crossover toe typically presents in a varus position at the MPJ as a hammertoe deformity. This typically occurs at the second MPJ and is coupled with a hallux valgus deformity.¹

A curly toe deformity, also known as a “cock-up toe,” is typically isolated to the fourth and fifth toes. The toe appears curved but is not angulated in the frontal plane.

A Closer Look At Biomechanical Etiologies

McGlamry described three etiologies for hammertoes: flexor stabilization, flexor substitution and extensor substitution.³

Flexor stabilization typically occurs in a pronated foot and the flexor digitorum longus gains mechanical advantage over the interossei muscles. Hallmark clinical signs include an adductovarus deformity of the fourth and fifth digits.



Flexor substitution typically occurs in a supinated foot in the late stage of gait. This allows for the flexors to gain mechanical advantage over the interossei muscles. In regard to this deformity, it is common to note a weak triceps surae with the deep posterior muscles attempting to accommodate for the weak triceps muscle.

Extensor substitution, sometimes referred to as extensor recruitment, occurs in the swing phase of gait when the long extensors have gained a mechanical advantage over the lumbricali muscles.

While each entity may exist separately, it is more ordinary to recognize concomitant etiologies. This is particularly true when more complex stages of clinical digital deformities are present.

Dynamic etiologies may clarify a given deformity chiefly when the deformity is exacerbated by standing and ambulation. Imbalances among the intrinsic and extrinsic muscles, and tendons are very common in lesser toe deformities.⁴

Neuromuscular disorders such as diabetic peripheral neuropathy, in which there is a denervation to the intrinsic muscles of the foot, lead to overpowering by the extrinsic motor units. As a result, the intrinsic muscles are unable to flex the metatarsophalangeal joints or extend the interphalangeal joints to balance the forces of the extrinsic muscles and tendons, consequently leading to digital deformities.



Inflammatory arthropathies such as rheumatoid arthritis can be the cause of digital deformities by destabilization of lesser MPJs. This is initially caused by synovitis and leads to eventual deterioration of the MPJ collateral ligaments as well as the plantar plate. Eventually the metatarsophalangeal joints subluxes and dislocates, leading to the extrinsic muscles gaining mechanical advantage over the intrinsic muscles.¹ Digital deformities can also be caused by compensation for other deformities such as hallux abducto valgus.

Keys To The Clinical Exam

Obtain a thorough patient history. Give particular consideration to the patient's neurological history and exam. Evaluate the patient for motor and sensory neuropathy as well as intrinsic muscle weakness. Perform the evaluation while the patient is sitting, standing and ambulating. One will commonly identify dynamic deformities while the patient is standing and ambulating. Determine whether the deformities are rigid, semi-rigid and/or flexible.

The presence of metatarsalgia, diffuse hyperkeratosis, intractable plantar hyperkeratosis or ulceration is often related to the digital deformities. For example, a subluxation and dislocation of a MPJ can cause the proximal phalanx to exert excessive plantar directed pressure on a metatarsal head. This results in increased pressure on the metatarsal. This additional pressure can result in thickened skin lesions and possible ulcerations.

One should perform the digital Lachman test to determine the stability of the metatarsophalangeal joint.⁵ Note the presence of hard and soft corns of the digits as well as distal clavi and ulcerations secondary to increased pressure points.



Essential Considerations In Selecting The Optimal Procedure

Prior to embarking on a surgical correction of a toe deformity, one must understand and identify the etiology of the problem.

Is the bone (proximal, middle, distal phalanx or metatarsal) really diseased/deformed or abnormal, or is it just contracted? Is the true problem with the bone or with the joint contracture? If it is a joint contracture, then what caused the contracture? If it is not the bone, then why deform a normal appearing osseous segment of a toe? If the joint is contracted, should one remove and correct/balance the deforming force? If one removes the deforming force, what is the chance of recurrence?

In my experience, most deformities are associated with an abnormal pull of the long flexors or extensors that have caused the toe to deform. The deformities are historically classified as flexible, semi-rigid or rigid. One must balance the flexors or extensors in order to prevent recurrence or continued progression of the deformity.

For example, surgeons commonly perform an arthroplasty for a hammertoe at the proximal interphalangeal joint. A "typical" arthroplasty entails resection of the head of the proximal phalanx and relaxing — but not balancing — the long extensor and flexor tendons.

Typically, this results in shortening of the toe and resection of a normal bone and cartilage. If one performs these "typical" arthroplasties in patients who present with dynamic deformities such as extensor recruitment/substitution or flexor stabilization, the contracture will have a high probability of recurrence over a period of time.

Selecting the most appropriate procedure for correction of digital deformities requires a thorough understanding of the biomechanics and etiology, and a good clinical and radiographic exam of such

deformities. In most situations, tendon transfer techniques for the long flexors and/or long extensors may be more beneficial, especially in patients with muscle tendon imbalance or when significant compromise of the plantar plate exists.

Typically, tendon transfers are reserved for only flexible deformities. In my experience, tendon transfers, when performed correctly, can be effective for semi-rigid and sometimes rigid deformities. Surgeons can use tendon transfers alone or in conjunction with other techniques. While some patients will benefit from techniques of flexor tendon transfers, others may require transfer of the extensor tendons to the midfoot (i.e. a modified Hibbs suspension procedure). These concepts are not new. However, the original Hibbs and Girdlestone procedures have been modified to make them more user friendly.^{6,7}

How To Perform The Modified Girdlestone-Taylor Procedure

The modified Girdlestone-Taylor procedure is for flexion contractures of the distal interphalangeal joint and/or proximal interphalangeal joint. One can perform the procedure through a midline incision approach on the lateral aspect of the hallux and the medial aspect of the second, third, fourth and fifth toes. It is recommended that one use fine double skin hooks for retraction in order to avoid soft tissue compromise.

Deepen the incisions in the same plane but be careful to avoid the neurovascular bundles by dissecting to the plantar aspect of the osseous structures. Identify the flexor digitorum longus and trace it distally to its attachment to the distal phalanx. Detach the distal aspect of the flexor digitorum longus from the distal phalanx and direct it proximal to the web space.

Proceed to direct your attention to the flexor digitorum brevis tendon. Perform a tenotomy (both the medial and lateral slips) and capsulotomy at the interphalangeal joint (for a flexion contracture of the proximal interphalangeal joint). If the distal interphalangeal joint is contracted, perform a capsulotomy as well.

Insert a K-wire (preferably 0.062 inches) from the distal tip of the distal phalanx to the base of the proximal phalanx. With the toe in anatomical alignment (in relation to the metatarsal), suture the flexor digitorum longus tendon to the extensor soft tissue of the proximal phalanx under physiologic tension. This will aid in the plantarflexion of the toe.

Advantages. With the scars located on the lateral aspect of the hallux and the medial aspect of the second, third, fourth and fifth digits, the procedure leaves a much more cosmetic pleasing result. Postoperatively, there is a much more natural clinical look to the toes. The resulting bursa, hyperkeratosis and ulceration eventually dissipate as one corrects the deforming forces and relieves the pressures. Since the surgeon only performs a plantar joint capsulotomy, joint instability does not occur. Therefore, frontal (rotation) and transverse plane deviation deformities do not occur. There is no surgery on bone. Therefore, one can minimize the long-term edema which often occurs after bony procedures.

Additionally, since there is no surgery on the bony structures, there is no rotation, shifting, malalignment or shortening of the digits. The tendon transfer treats the underlying pathology: the dynamic deforming force of the tendon. Therefore, this eliminates the need to disturb the natural osseous structures of the three phalanxes. After addressing the underlying pathology and removing the deforming forces, you can typically remove the K-wire after two weeks. Lastly, if there is a complication, one could always perform a bony procedure if necessary.

Disadvantages. In terms of disadvantages, this is a more technically challenging surgical procedure. The approach makes for a difficult space to work between toes. While possible complications are similar to those with any other digital surgery, more unique complications to this procedure consist of overcorrection or hyperextension of the corrected joints, maceration and wound issues of the incision sites secondary to interdigital contact.

What You Should Know About The Modified Hibbs Procedure

The modified Hibbs procedure is indicated for patients who exhibit extensor substitution/recruitment. Dorsal subluxations/dislocations at the MPJ are frequently linked with claw toes and hammertoes. These deformities typically result with the recruitment of a tight extensor digitorum longus (extensor substitution/recruitment) to support dorsiflexion against a tight posterior muscle group (equinus deformity).⁶

Starting at the second MPJ, make an oblique dorsal incision to the base of the fourth metatarsal. Deepen this incision in the same plane and avoid all neurovascular structures. Be sure to avoid and preserve the superficial nerves in the subcutaneous tissues as these will be running longitudinally. Great care of the soft tissue is essential and fine double skin hooks are recommended for retraction in order to avoid soft tissue compromise.

Identify the extensor tendons (extensor digitorum longus and brevis) and separate only these tendons from the subcutaneous tissues. The extensor digitorum longus and brevis tendons are deep to the superficial nerves. One should separate and track these longitudinally, and use caution to avoid neurovascular structures.

Isolate the second, third and fourth extensor digitorum longus tendons. Tenotomize and clamp these tendons using a soft tissue clamp as far proximal within the incision as possible.

Identify the fifth extensor digitorum longus tendon and perform a Z lengthening in order to release the tension and contracture. Tenotomize the second, third and fourth extensor digitorum brevis tendons as far distal as possible (at the metatarsophalangeal joint level).

Perform a complete capsulotomy at the second, third, fourth and fifth MPJs. This facilitates release of all contractures via sharp dissection and a McGlamry elevator.

Perform additional soft tissue procedures to the digits. Be sure to address flexion contractures of the second, third, fourth and fifth digits (similar to what you would do with a Girdlestone–Taylor procedure).

Insert a 0.062 K-wire from the distal aspect of the toes through the distal interphalangeal joint, the proximal interphalangeal joint and the metatarsophalangeal joint to the base of the second, third, fourth and fifth metatarsals. Ensure good anatomical alignment of the distal interphalangeal joint, the proximal interphalangeal joint and the metatarsophalangeal joints.

Proceed to perform a tendon transfer (a weave graft) of the distal stump of the proximal extensor digitorum brevis into the most proximal portion of the distal extensor digitorum longus stump. Perform the transfer under physiological tension with the digits in good anatomic position. Following the transfers, suture the Z-lengthened fifth extensor digitorum longus with physiologic tension and good anatomic alignment.

Then pass the distal stumps of the proximal portion of the third and fourth extensor digitorum longus tendons deeply to the soft tissue structure (to avoid pressure on the neurovascular structures) to the level of the second distal stump of the proximal extensor digitorum longus tendon.

Suture together the distal stumps of the proximal portion of the second, third and fourth extensor digitorum longus tendons, and transfer them into the peroneus tertius or the periosteum of the intermediate cuneiform. Perform this with the surgical assistant loading the foot 90 degrees relative to the leg.

Make the sutures under physiologic tension for tendon balancing. This method facilitates a mechanical gain in dorsiflexion.

The surgeon typically closes the deep subcutaneous tissues with 4-0 Monocryl. Be sure to avoid the superficial neurovascular structures. Close the skin using 4-0 Prolene.

Following K-wire removal, one should emphasize physical therapy for the patient in order to help resolve any edema and soften the postoperative fibrosis and scar tissue formation.

Emphasize active and passive manipulation of the joints that underwent surgery. Typically one instructs patients about home exercise programs they can use to maintain plantarflexion and dorsiflexion at the surgical sites.

Weighing The Pros And Cons Of The Modified Hibbs Procedure

Advantages. This procedure will address the underlying pathology and eliminate the chance of recurrence. There is typically less edema to the digits since one is not performing surgery on the digits. Since this procedure enables you to address the underlying pathology and remove the deforming forces, I typically remove the K-wire at two to four weeks, depending on the severity and how long the deformity had been present.

Postoperatively, the digits provide more of a natural look because there is no surgery on the toes. This procedure is specifically for those patients who have a muscle tendon imbalance (extensor substitution/recruitment). This procedure assists in rebalancing the foot and aids in dorsiflexion.

Disadvantages. The patients will have a scar to the forefoot. If one does not manage the soft tissue with great care, wounds can develop into a potential problem as the soft tissue layer of a forefoot is more often than not very thin. The superficial nerves can be irritated by the pull of the incision and scar tissue. Subsequent to this surgical procedure, patients will have a decline in extensor power and range of motion of the digits.

The patients must be well informed prior to the surgery that the aim of the surgery is to balance the foot. Those patients in need of a modified Hibbs procedure have an overpowering of the long extensors.

One needs to convey this to the patients and explain that the objective of the surgery is to “weaken” their extensor power (their long extensor tendons are overpowering the short extensors) by transferring a weaker extensor digitorum brevis tendon into the distal extensor digitorum longus insertion.

The surgeon can also explain to patients that they do not need fine movements with the toes as they do with their hands. They need to be able to dorsiflex and plantarflex the digits in order to ambulate effectively. The surgery should also remove the deforming forces, improve function and relieve the patient’s pain and symptoms.

Pertinent Insights On Managing Surgical Complications

Digital surgery is challenging and can be burdened with complications that will be discouraging to both the patient and surgeon.

The most devastating complication of digital surgery is amputation. Amputations can occur secondarily to dysvascularity from poor blood supply (peripheral vascular disease) or from correction of a severely contracted long-term deformity that goes into vasospasm once surgery straightens the toe.

More common complications include pin site infections, pin breakage (using too small of a diameter), superficial and deep wound dehiscence, under-correction, over-correction, infection and swelling of the toes and/or forefoot.

In Conclusion

Digital deformities have a mixture of underlying etiologies. When there is a surgical indication, it is essential for the surgeon to identify the etiology in order to properly address the deformity and increase the probability of a successful long-term outcome.

In my experience, I have found that performing tendon transfers for digital deformities in the appropriate patient leads to a more predictable outcome for patients. While it is not unusual to have complications, they are usually minor and one can treat them simply and promptly.

Dr. DiDomenico is affiliated with the Forum Health/Western Reserve Care System in Youngstown, Ohio. He is the Section Chief of Podiatry at St. Elizabeth's Hospital in Youngstown, Ohio. He is the Director of the Reconstructive Rearfoot and Ankle Surgical Fellowship within the Ankle and Foot Care Centers and the Ohio College of Podiatric Medicine. Dr. DiDomenico is a Fellow of the American College of Foot and Ankle Surgeons.

For further reading, see "Emerging Concepts In Hammertoe Surgery" in the September 2009 issue of Podiatry Today or "Point-Counterpoint: Is Plantar Plate Repair More Effective Than Flexor Tendon Transfer?"

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