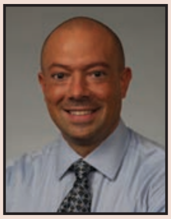
# Is The Flexor Digitorum Longus Tendon Transfer Effective For Stage 2 Adult-Acquired Flatfoot?

## Point



**Yes.** Citing multiple advantages, this author emphasizes that combining a flexor digitorum longus tendon transfer with a gastrocnemius recession and medial displacement calcaneal osteotomy can provide pain relief to patients with stage 2 posterior tibial tendon dysfunction.

*By William T. DeCarbo, DPM, AACFAS*

Posterior tibial tendon dysfunction (PTTD) is a common pathology that foot and ankle specialists encounter. Posterior tibial tendon dysfunction is characterized by a valgus hindfoot, flattening of the longitudinal arch of the foot and abduction of the forefoot. This is a progressive deformity that begins with the foot being flexible but it can become rigid over time. Johnson and Strom classified Stage 1 PTTD as a foot with an intact arch, Stage 2 as a flexible flatfoot deformity and Stage 3 as a fixed flatfoot deformity.[1] Myerson later introduced Stage 4 as an underlying Stage 2 or Stage 3 deformity with the addition of deltoid ligament laxity leading to a valgus tilt of the ankle joint.[2]

Initial treatment is based on the degree of deformity and flexibility at the initial presentation. Conservative treatment includes orthotics or ankle foot orthoses to support the posterior tibial tendon and the longitudinal arch, anti-inflammatories, activity modification and physical therapy. If conservative treatment fails, consider offering surgical intervention. For a Stage 1 deformity, a posterior tibial tendon tenosynovectomy or primary repair may be indicated. For Stage 2, a combination of Achilles lengthening with calcaneal osteotomies and tendon transfers is common.[3] In Stage 3 or 4 PTTD, isolated fusions may be indicated.[4]

The normal biomechanics of the posterior tibial tendon are to invert the subtalar joint (STJ), plantarflex the ankle and adduct the forefoot.[5] The posterior tibial tendon also stabilizes the hindfoot in conjunction with the gastrocnemius-soleus complex by inverting the heel during gait, which locks the transverse tarsal joints, converting the foot into a rigid lever for push-off.[6] This initial inversion of the hindfoot by the posterior tibial tendon is crucial in the gait cycle for normal ambulation. Any pathology that attenuates or damages the posterior tibial tendon may have an adverse effect on this function.[7]

With pathology of the posterior tibial tendon, its antagonist, the peroneus brevis tendon, acts as a deforming force in the development of hindfoot valgus and forefoot abduction.[5,8] This leads to the hindfoot not being supinated during heel strike, resulting in the midfoot remaining flexible with no rigid lever for push-off. Over time, the longitudinal arch decreases due to the secondary static ligaments (spring ligament) stretching, resulting in abduction of the forefoot.[9]

### A Closer Look At Tendon Transfers And Adjunctive Procedures For Stage 2 PTTD

In Stage 2 flexible PTTD, tendon transfers to help restore the longitudinal arch and the posterior tibial tendon are common. Which tendon to transfer depends on multiple issues including the axes of motion around the ankle and hindfoot, the muscle strength of the individual tendons and the phase the muscle fires in the gait cycle.[10]

Silver and colleagues calculated the strength of the posterior tibial tendon to be 6.4, the anterior tibial tendon to be 5.6, the peroneus longus 5.5, the flexor hallucis longus 3.6, the peroneus brevis 2.6 and the flexor digitorum longus tendon to be 1.8, with muscle strength relative to the proportional cross-sectional area.[11] The posterior tibial tendon, flexor hallucis longus tendon and the flexor digitorum longus tendon all fire in the same phase of the gait cycle.[5] Due to the relative strength of the flexor digitorum longus tendon, surgeons often combine its transfer to augment the posterior tibial tendon with adjunctive procedures to decrease the biomechanical stress on the transferred tendon.[5]

These adjunctive procedures improve the longitudinal arch of the foot by decreasing the antagonist hindfoot eversion force and increase the overall hindfoot inversion force by increasing the moment arm of the transferred tendon.[5] The typical adjunctive procedures with Stage 2 PTTD are a gastrocnemius-soleus recession or a medial displacement calcaneal osteotomy in conjunction with

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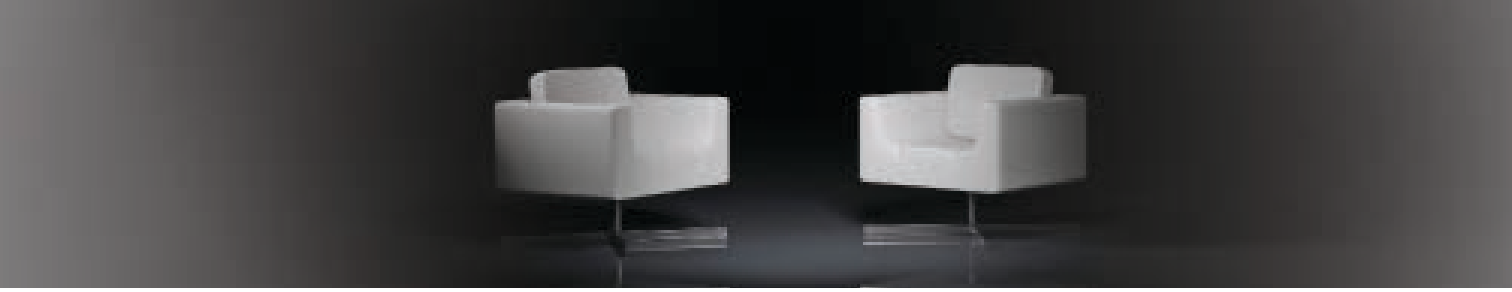
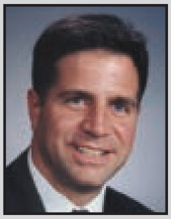


# Counterpoint



**No.** These authors say performing the flexor digitorum longus tendon transfer is unnecessary in most cases and this tendon lacks the long-term mechanical advantage to stabilize the midfoot in patients with stage 2 adult-acquired flatfoot.

*By Lawrence A. DiDomenico, DPM, FACFAS, Ramy Fahim, DPM, AACFAS, and Zachary Thomas, DPM*

Adult-acquired flatfoot deformity is characterized by a collapse of the medial longitudinal arch and loss of the mechanical advantage of the posterior medial soft tissue structures, including the posterior tibial tendon. Key initially described a chronic partial rupture of the posterior tibial tendon.[1] Further literature confirmed an association with this pathology and in fact, "dysfunction" of this posterior tibial tendon with adult-acquired flatfoot deformity.

Various authors have extensively reviewed conservative and surgical management of flatfoot deformity, but debate still exists in the surgical management of stage 2 deformities, especially in the presence of medial column instability and posterior tibial tendon dysfunction (PTTD).

We will critically review and discuss a surgical technique that consists of procedures of various flatfoot reconstructions without performing a flexor digitorum longus tendon transfer. We believe if one addresses and evaluates the underlying pathology, there is no need to perform the flexor digitorum longus tendon transfer in most cases.

After this reconstructive surgery, postoperative immobilization enables the posterior tibial tendon to heal and remodel without the need for further surgery. By eliminating the need for an additional procedure, one doesn't have to address concerns about morbidity that are associated with a flexor digitorum longus tendon transfer.

Furthermore, we do not believe that a much smaller flexor digitorum longus tendon can adequately replace the work of a much larger and stronger posterior tibial tendon. Additional benefits include less operative time, less anesthesia time, better cosmesis, reduction in postoperative edema, less chance of nerve injury and quicker postoperative rehabilitation.

## A Guide To Flatfoot Classification

Johnson and Strom described stages 1-3, and Myerson described the fourth stage.[2,3] Stage 1 is painful tenosynovitis of the posterior tibial tendon. Stage 2 consists of a flatfoot deformity with pain and dysfunction of the posterior tibial tendon. Patients maintain normal hindfoot motion during that stage and are able to perform the double limb heel rise test, but are unable to perform the single limb test. Stage 3 involves dysfunction of the posterior tibial tendon with signs of stiffness and arthrosis of the hindfoot.[2] Finally, Stage 4 deformities are a progression of stage 3 with associated tibiotalar asymmetry as a result of the prolonged hindfoot valgus.[3]

We should note that this classification system provides an organized and categorized system to define the stages of the deformity. However, the system lacks observer reliability as there exists a spectrum of underlying pathologies between the stages. For example, consider the role of the lateral column/midtarsal joint and the instability of the medial column in flatfoot deformity.

## What The Literature Shows On Adjunctive Procedures With Posterior Tibial Tendon Augmentation

For the purposes of this article, we will focus on the operative management of stage 2 deformities and review the outcomes of various combination osteotomy procedures with augmented flexor digitorum longus tendon transfers.

**Medial calcaneal osteotomy and posterior tibial tendon augmentation.** Surgeons commonly perform an osteotomy to protect the tendon transfer by improving the supinatory capacity of the gastroc soleus complex.[4] Brodsky noted significant improvements in the postoperative gait analysis for patients undergoing medial calcaneal osteotomies in conjunction with flexor digitorum longus transfer to the navicular tuberosity.[5] He specifically noted improvements in cadence, stride length and ankle push-off. Furthermore, studies by Myerson, Fayzi, Wacker, Guyton, Sammarco and Hockenbury and their respective colleagues demonstrated a high rate of successful results

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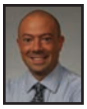

# Point

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the flexor digitorum longus transfer. A medial displacement calcaneal osteotomy reverses the coronal plane hindfoot malalignment. This medial displacement helps medialize the pull of the Achilles tendon to reduce the antagonist's pull on the relatively weak flexor digitorum longus tendon.[12-14]

## Step-By-Step Surgical Insights

My approach to Stage 2 PTTD that has failed conservative treatment is a gastrocnemius-soleus recession with a medial displacement calcaneal osteotomy and transfer of the flexor digitorum longus tendon through a dorsal to plantar bone tunnel through the navicular. The flexor digitorum longus tendon transfer acts to support the longitudinal arch of the foot and augment the posterior tibial tendon. This transfer also gives a static support to the often attenuated spring ligament. Surgeons most often inferiorly reflect the posterior tibial tendon for later repair.

If the posterior tibial tendon disease process is extensive, resect it. This diseased tendon may cause persistent pain if one does not resect it, leading to dissatisfaction of the patient postoperatively.[5] Trevino, Moseir and their respective colleagues showed that stage 2 posterior tibial tendons were diseased microscopically with tendinosis characterized by mucinous degeneration, fibroblast hypercellularity, chondroid metaplasia and neovascularization.[15-17] This results in a disruption in the collagen bundle structure and orientation.

One can access the insertion of the posterior tibial tendon to determine if an accessory ossicle is present. If so, excise this ossicle. After either reflecting or resecting the posterior tibial tendon, identify the flexor digitorum longus tendon sheath and expose the tendon. Carry dissection distally to the knot of Henry. With the ankle in maximum plantarflexion and the lesser digits in maximum plantarflexion, to decrease the tautness of the flexor digitorum longus tendon, transect the tendon. Take care to avoid the medial plantar nerve, which lies just plantar to the tendon. Transecting the flexor digitorum longus at the knot of Henry leaves the interconnections between the flexor digitorum longus and flexor hallucis longus intact, allowing for preservation of the flexor hallucis longus function.[18-20]

Then pass the flexor digitorum longus from inferior to superior through the navicular bone tunnel. The forefoot is supinated and the surgeon sutures the flexor digitorum longus tendon in a side-to-side anastomosis back to itself. Once this transfer is complete, advance the posterior tibial tendon to augment the repair and suture the posterior tibial tendon into the transferred flexor digitorum longus tendon.

## What Other Studies Reveal

Studies have shown an increase in residual strength of the transferred muscle and tendon secondary to hypertrophy.[21,22] The decreased muscle mass of the antagonistic muscles as compensation from the medial displacement calcaneal osteotomy may also contribute to a relatively increased strength of the flexor digitorum longus tendon transfer. Wacker and colleagues compared magnetic resonance imaging (MRI) in 12 patients with unilateral stage 2 PTTD with the asymptomatic leg.[21] The MRI showed a mean atrophy of the posterior tibial tendon of 10.7 percent and a hypertrophy of the flexor digitorum longus tendon of 17.2 percent. The study also showed hypertrophy of the flexor digitorum longus tendon to be 44 percent greater than the contralateral side when the posterior tibial tendon received resection.

Many outcome studies exist on the flexor digitorum longus tendon transfer for Stage 2 PTTD. Most recently, Kou and coworkers published a prospective study of 24 patients who underwent a flexor digitorum longus tendon transfer to the navicular, a double calcaneal osteotomy and gastrocnemius recession.[23] Twenty-three patients were available for a two-year follow-up. All patients had statistical improvement in the Visual Analog Scale, the Foot And Ankle Outcome Survey, the Assessment of Daily Living, the Rowan Foot Pain Assessment Questionnaire and SF-12 scores at one year postoperatively with maintenance of the improvement at two years with good functional results.

## In Conclusion

Despite the relative lack of strength of the flexor digitorum longus tendon in comparison to the posterior tibial tendon, there are multiple advantages to transferring this tendon to augment the posterior tibial tendon. The flexor digitorum longus tendon originates adjacent to the posterior tibial tendon and runs with it to its distal insertion. This allows for the posterior tibial tendon repair or resection and the flexor digitorum longus tendon transfer through the same incision. The flexor digitorum longus tendon also does not cross the posterior tibial neurovascular bundle, thus avoiding any potential impingement. The flexor digitorum longus tendon fires in the same phase of the gait cycle of the posterior tibial tendon.

The flexor digitorum longus transfer with subsequent gastrocnemius recession and calcaneal osteotomy offer patients a predictable outcome that increases function and eliminates pain. ■

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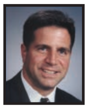

## Counterpoint

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> We do not believe that a smaller tendon (flexor digitorum longus tendon) can predictably provide the mechanical advantage to stabilize the midfoot in the long term in cases in which patients suffer from stage 2 PTTD.

with short to intermediate follow-up.[6-10] Those studies were mostly level IV case series but nonetheless demonstrated predictably good outcomes.

These studies do not, however, explain the extent of involvement of the flexor digitorum longus transfer in maintaining longitudinal arch and transverse plane correction, specifically on a long-term basis.

**Lateral column lengthening and posterior tibial tendon augmentation.** Evans originally described this procedure in the pediatric population and with the use of a tricortical graft.[11] Correction of this deformity occurs by adducting and plantarflexing the midfoot around the talar head. Hinterman and Toolan and their respective coworkers showed promising results in their case series.[12,13] However, other level IV studies have reported complications of forefoot varus, lateral column overload, nonunion and graft failure.[14]

**Double calcaneal osteotomies and posterior tibial tendon augmentation.** The combination of osteotomies provides a powerful correction and further decreases the load on the posterior-medial structures in comparison to single osteotomy procedures. In doing so, there is also improvement in overall alignment of the forefoot on the midfoot. Moseir-LaClair and colleagues demonstrated this point in their case series as well.[15] However, the authors drew no direct conclusion regarding the individual benefit of the flexor digitorum longus tendon transfer in this procedure.

With a double calcaneal osteotomy, there is a greater potential for realignment and thus the need for the flexor digitorum longus tendon transfer as an augmentation for the posterior tibial tendon is questionable. In fact, the question of how much structural support the flexor digitorum longus tendon transfer provides is unanswered in lieu of using more predictable osteotomies that provide powerful deformity corrections in three planes.

### What You Can Learn From The Authors' Surgical Approach

In addition to ensuring supine positioning of the patient on the operating table and the use of general anesthesia, one may use an ipsilateral pneumatic thigh tourniquet to aid hemostasis. We perform a repeat Silfverskiold test intraoperatively to confirm clinical testing.[16] In our experience, approximately 90 percent of patients have presented with isolated gastrocnemius equinus when presenting with symptomatic PTTD. One can address the posterior muscle group contracture by either a gastrocnemius recession (endoscopic or open), or a tendo-Achilles lengthening, which is dictated by the Silfverskiold test results.

Then execute extra-articular osteotomies of the hindfoot via a medializing percutaneous calcaneal displacement osteotomy.[17] Use a Gigli saw to execute the osteotomy. The surgeon then evaluates the midtarsal joint intraoperatively. If the midtarsal joint is unstable with the subtalar joint in a neutral position, perform an Evans osteotomy through an oblique lateral incision with the use of a tricortical allograft.

The fixation of our choice is through two large partially threaded cancellous cannulated screws. We employ an interfragmentary compression screw, partially threaded, in the superior calcaneus compressing the calcaneal displacement osteotomy. Insert a second screw in the inferior portion of the calcaneus. This screw is a large, "dual use," long-thread, cannulated, cancellous screw to compress the calcaneal slide osteotomy. The distal portion of the screw functions as a positional screw that maintains the Evans correction without compression while the proximal portion of the screw provides interfragmentary compression. This approach allows us to achieve a significant amount of correction with minimal dissection to the medial and lateral soft tissues through the use of intramedullary fixation. The double calcaneal osteotomy with gastrocnemius recession also allows the surgeon to preserve the essential hindfoot joints while permitting realignment arthrodesis of the nonessential joints of the midfoot as necessary.

Then evaluate the medial column and address it for hypermobility at the affected joints. Stabilize the identified instability/deformity through a medial approach. In doing so, one stabilizes the first ray and positions it to create a tripod effect.

In our previous case series of 34 patients, we accomplished considerable radiographic correction in pursuing extra-articular hindfoot osteotomies (medializing calcaneal osteotomy and/or Evans lateral column lengthening) as

well as medial column fusions.[18] Patients demonstrated successful postoperative outcomes over an average follow-up period of 14 months.

## Other Pertinent Points

Addressing the structural corrections at the apex of the deformity significantly relieves the stress on the posterior tibial tendon. Cadaveric studies have proven that realigning the hindfoot can decrease the elongating strain on the posterior tibial tendon by 51 percent.[19] This redirects the transverse plane deformity and the loading of forces on the foot as the medial longitudinal arch stabilizes while preserving essential motion at the hindfoot. Positioning the heel in rectus alignment with the leg eliminates the abnormal pull of the tendo-Achilles and mechanical advantage of the peroneus brevis.

Another important advantage of avoiding the flexor digitorum longus tendon transfer is decreasing the operative morbidity. This decision is both patient- and surgeon-friendly for the following reasons:

- less operating time (including tourniquet time) as well as anesthesia time;
- fewer incision sites;
- better cosmesis;
- reduced postoperative edema; and
- quicker postoperative rehabilitation as there is less morbidity.

Ultimately, the use of flexor digitorum longus tendon transfers for posterior tibial augmentation in flatfoot deformity correction has been well documented in the foot and ankle literature. However, the exact role of those transfers in the overall deformity correction still remains an area of debate. There is no proof that one can predictably reproduce the structural support with those tendon transfers alone.

Paradoxically, Murray and colleagues have demonstrated a significantly smaller cross-sectional area of the flexor digitorum longus tendon by 50 percent in comparison to the posterior tibial tendon counterpart.[20] In addition, by applying various levels of plantar load, the authors showed the posterior tibial tendon to tolerate twice the amount of plantar load than that of the flexor digitorum longus tendon.

## Final Words

In essence, in relying on the flexor digitorum longus tendon transfer, we would be replacing the function of a weakened tendon with an inherently weak tendon for structural support. We offer a different perspective and advocate for structural reconstruction of the deformity to establish a mechanically stable and functional foot.

Rather than performing the flexor digitorum longus tendon, we choose to offload the posterior tibial tendon by creating a mechanical advantage. With the time the patient is in a non-weightbearing, below-the-knee cast postoperatively, the tendon has sufficient time to heal. When the patient returns to weightbearing, the foot is mechanically balanced and the stress that caused the initial symptoms is neutralized.

In conclusion, we do not believe that a smaller tendon (flexor digitorum longus tendon) can predictably provide the mechanical advantage to stabilize the midfoot in the long term in cases in which patients suffer from stage 2 PTTD. Additionally, our experience demonstrates that the diseased posterior tibial tendon does respond to nonoperative care by being immobilized in the postoperative period of the surgical reconstruction. The reconstructive foot surgery provides a mechanical advantage and offloads the stress from the posterior tibial tendon. We suggest this process is similar to other successful immobilization techniques for other tendonopathies.

In our experience, we reserve the flexor digitorum longus tendon transfer for those few select cases in which one has identified a significant tear of the posterior tibial tendon. ■

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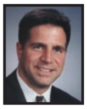
# Counterpoint

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*For further reading, see "Current Concepts In Surgery For Adult-Acquired Flatfoot" in the October 2012 issue of Podiatry Today.*