Managing the adult flexible flatfoot deformity. An evolution of thinking

Terapija fleksibilnog spuštenog stopala u odraslih. Razvoj stavova

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Abstract. The adult flexible flatfoot has a vast spectrum of deformity, which makes decision making for management quite challenging. Furthermore the patient's activity levels also dictate the kind of surgical intervention which may need to be adopted. This article highlights the evolution in the classification and treatment rationale of this condition based on the author's experiences. We also describe certain new techniques such as an allograft tendon reconstruction specifically the work up and surgical techniques which have formed part of our treatment algorithm.

Key words: adult; decision making; flatfoot; treatment

Sažetak. Fleksibilno spušteno stopalo u odraslih može biti uzrokovano velikim brojem čimbenika, što operacijsko liječenje čini zahtjevnim. Na vrstu operacijskog zahvata u liječenju tog deformiteta utječe i aktivnost pacijenta. U ovom radu naglasak je stavljen na evoluciju klasifikacije deformiteta te pristup liječenju temeljen na iskustvu autora. Opisane su i nove kirurške tehnike, kao što je primjena alogeničkog tetivnog presatka, razvijene kako bi postale sastavni dio postupka u liječenju tog deformiteta.

Ključne riječi: liječenje; odlučivanje; odrasli; spušteno stopalo

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INTRODUCTION

Management of the adult flexible flatfoot deformity has changed and evolved significantly over the past 30 years. Beginning in the early 1980's it was common to perform a flexor digitorum longus (FDL) transfer or tenodesis to the ruptured posterior tibial tendon (PTT). This ignored the forces on the hindfoot as a result of the rupture of the PTT and it was only in the late 1980's Myerson introduced the concept of adding a calcaneus osteotomy to the FDL transfer for management of the flexible flatfoot[1]. Although this approach was an improvement in the management of the flatfoot, it was still quite inadequate because it failed to recognize the many variations of the type of flatfoot deformities. To understand this further, one must study the classification systems for the flatfoot that have been used over these past decades, since these give an indication as to what the surgical options were considered historically for each deformity.

> A classification system of the flatfoot is only helpful if it describes and characterizes all types of deformity, and provides a corresponding treatment alternative for every aspect of deformity. Many surgeons recognized that few adult acquired flatfoot deformities can be placed into one of the four stages. Probably the most detailed and clinically useful system recognized is the one devised by Myerson et al in 2007.

The first attempt at a classification of the adult acquired flatfoot was by Johnson and Strom in the late 1980's[2]. This was quite simplistic, and divided the problem into three stages: Stage I was considered to be an early flatfoot associated with tenosynovitis but with minimal flatfoot deformity, and if non surgical treatment failed, they proposed a tenosynovectomy of the PTT. This however completely ignored the fact that tenosynovitis is invariably associated with a slight flatfoot and a tight gastrocnemius. Therefore, we would now routinely add a medial translational calcaneus osteotomy with or without a gastrocnemius recession to the tenosynovectomy for early stage disease. Their stage II consisted of a flexible flatfoot deformity, but the type of flexibility and the apex of the deformity were never characterized. For most of the 1980's this type of deformity was treated with a flexor digitorum longus (FDL) transfer. Some surgeons transferred the FDL into the navicular, and some as a tenodesis to the ruptured PTT, but no recognition of the different types of midfoot and hindfoot deformity was made at this time[3]. In the late 1980's Myerson introduced the concept of adding a medial translational calcaneus osteotomy to the FDL transfer for management of the flexible flatfoot which became a routine part of this reconstruction for many surgeons[1]. While this addressed the valgus deformity of the heel, it still failed to address the imbalance of muscle forces on the hindfoot following rupture of the PTT. Stage III consisted of rigid deformity with hindfoot valgus in which the subtalar joint was not correctable to neutral, and triple arthrodesis was the treatment of choice. While the majority of rigid deformities do indeed require a triple arthrodesis, there are many additional procedures which must also be considered as part of the spectrum of a rigid flatfoot deformity. Myerson subsequently added a Stage IV to this rudimentary classification system which included valgus deformity of the ankle associated with a rupture of the deltoid ligament[4].

A classification system of the flatfoot is only helpful if it describes and characterizes all types of deformity, and provides a corresponding treatment alternative for every aspect of deformity. Many surgeons recognized that few adult acquired flatfoot deformities can be placed into one of the four stages described above. Probably the most detailed and clinically useful system recognized is the one devised by Myerson et al in 2007 which is described in more detail below[5]. This system describes the characteristic clinical and radiographic findings for each stage and the treatment algorithm which should be adopted.

STAGE II: PTT RUPTURE WITH FLEXIBLE FLATFOOT

This stage is characterized by a collapse of the longitudinal arch, hindfoot valgus, weakness of inversion in a plantar flexed foot and inability to perform a single heel rise test. The pathology is a weak or ruptured tendon but the hindfoot is still mobile. It is further divided into three sub-stages with the first sub-stage being further subdivided into two categories.

Stage II A (Hindfoot valgus): This stage is characterised by a flexible hindfoot valgus. Once the heel is reduced to neutral position, the forefoot supination is either minimal or completely reducible (Stage IIA 1) or fixed (Stage IIA 2). Forefoot supination occurs because the forefoot always has to remain plantigrade regardless of what is happening in the hindfoot. So if the hindfoot moves into valgus, the forefoot has to adapt to these changes allowing the medial and lateral columns of the forefoot to remain in contact with the floor. If one reduces the heel into a neutral position, then these changes become apparent with a supination of the medial forefoot.

Stage II A-1 (Flexible forefoot varus): Once the flexible hindfoot is reduced to a neutral position, the forefoot varus which is also flexible can be corrected by plantar flexing the ankle and relaxing the contracture of the gastrocnemius.

Stage II A-2 (Fixed forefoot varus): This is differentiated from stage II A-1 by the fact that once the hindfoot deformity is corrected by manipulating the heel into neutral, the forefoot varus which is unmasked is fixed and does not correct by plantarflexing the ankle and easing the tension on the gastrocnemius.

Stage II B (Forefoot abduction): This stage is characterised by the presence of abduction at the forefoot as the key deformity in conjunction with the above mentioned hindfoot valgus and with or without forefoot supination. The abduction of the forefoot can occur either at the tarsometatarsal joints or the Chopart joints. The latter is identified by uncoverage of the talar head.

Stage II C (Medial ray instability): The relevant feature of this stage is medial ray instability. On correcting the hindfoot to a neutral position, the forefoot varus is not corrected even on attempted forced passive plantarflexion. This is due to an unstable medial column, since the first ray tends to dorsiflex with the heel being corrected, causing the foot to pronate on weight bearing and leading to subtalar impingement and pain. The instability can occur anywhere along the length of the medial column i.e. the first TMT joint, naviculocuneiform joint, talonavicular joint or a combination of these.

CLINICAL EXAMINATION

The clinical examination of a flexible flatfoot begins with inspection. There may be fullness along the course of the PTT with collapse of the medial longitudinal arch. The 'too many toes sign' is present as described by Johnson may be present but is usually more obvious in the advanced stages[6]. The PTT should be palpated and there may be tenderness due to the tenosynovitis. The patient is then asked to stand up on tiptoe for the 'heel rise test'. A single heel rise test is an excellent way to assess the integrity of the PTT and in a flexible flat foot, the hindfoot swings into varus. The PTT power is then tested with the patient seated and by asking the patient to invert his foot with the foot being plantarflexed. It is useful to note if the patient is able to invert the foot across the midline of the axis of the leg. This inversion action should be possible against resistance in the presence of an intact tendon. Once we have established that the hindfoot is correctible, focus should be then paid to what is occurring at the forefoot. This is done by holding the heel and bringing it into a neutral position and then assessing the whether the forefoot is supinated or not. If it is supinated, then the ankle is plantar flexed to determine whether the forefoot supination corrects itself. This occurs because the gastrocnemius complex is relaxed on plantarflexion and this corrects the deformity (Figure 1).

> The key to treatment of a flexible flatfoot deformity should aim to correct the essential components of the problem:
> - the hindfoot valgus
> - the tendon/muscle imbalance
> - forefoot supination.
> - forefoot abduction
> - the gastrocnemius contracture

Figure 1. Examination of forefoot varus. a) heel clasped behind uncorrected hindfoot which is in valgus; b) Note the forefoot varus after the hindfoot has been corrected to neutral. This forefoot deformity may then be flexible (corrects with ankle plantar flexion) or fixed (remains uncorrected with ankle platarflexion).

RADIOGRAPHIC FINDINGS

Radiographs are not required to make the diagnosis of a flat foot deformity nor a rupture of the PTT, as this is a clinical diagnosis based on examination. However they help to determine the presence of concurrent deformities, the degree of deformity and the stage of the disease. We advocate obtaining anteroposterior (AP) and lateral weight bearing radiographs of both feet, a hindfoot alignment view, and mortise views of both ankles, which are essential for the evaluation of the deformity[1].

OPERATIVE MANAGEMENT

The key to treatment of a flexible flatfoot deformity should aim to correct the essential components of the problem:

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- forefoot supination.
- forefoot abduction
- the gastrocnemius contracture.

Surgical management of the flexible flatfoot has undergone a vast change with joint preserving procedures being used more frequently as opposed to arthrodesis which was used in the past[7]. We look at some of these interventions listed below. Note that for all of these procedures, one has to determine if a gastrocnemius contracture is present, and this must be addressed surgically with a gastrocnemius recession. The technique for a gastrocnemius recession will not be discussed in this paper.

Correcting the hindfoot valgus deformity

There are only three procedures which will correct hindfoot valgus deformity: a medial displacement calcaneal osteotomy (MDCO), a subtalar arthroereisis procedure[8,9], or a subtalar arthrodesis[10,11,12]. It should be noted however that we do not use a subtalar arthroereisis as part of the management of the hindfoot valgus deformity in the adult. While this is a very useful surgical procedure for correction of the child's foot, our results of treatment in the adult have been poor, complicated by a high rate of pain and subtalar arthritis. If there is

Figure 2. The pre and post operative radiographs of an obese female patient with a rupture of the PTT and a rupture of the spring ligament. This was treated with a subtalar arthrodesis, transfer of the FDL, and a spring ligament reconstruction.

really significant flexible hindfoot valgus, a subtalar arthrodesis is a useful procedure to correct deformity, particularly in the obese patient for whom a standard correction may not be sufficient. This is clearly a departure from the concept of maintaining flexibility of the hindfoot in a Stage II rupture, but this is a procedure which we use for patients where there is a concern that the deformity will recur despite correct adherence to the steps of correction (Figure 2).

The MDCO is the mainstay of correcting the hindfoot valgus, and is either performed alone, or in conjunction with a lengthening of the lateral column of the calcaneus, and aims to change the calcaneal axis and hindfoot alignment. This in turn helps protect the soft tissue reconstruction by taking the tension off the tendon transfer or the reconstruction. It also realigns the pull of the Achilles tendon and the moment arm of the gastrocnemius soleus complex is converted from an evertor to an inverter of the hindfoot with medial translation of the calcaneus[13]. Originally described by Gleich in 1893[14], Koutsogiannis reintroduced the MDCO for the correction of the flatfoot deformity in 1971[15] and the application of this procedure to the management of the ruptured PTT was popularized by Myerson et al in the late 1980's. Since then several studies have shown the good results with this procedure[16-18]. We perform the MDCO osteotomy through a lateral oblique incision, one centimeter below the tip of the fibula in line with the osteotomy. A full thickness flap is developed with subperiosteal dissection down to bone. Care is taken to protect the branches of the sural nerve, although we warn patients that numbness is frequent post operatively. Retractors are placed on the plantar and dorsal aspects of the calcaneus for soft tissue protection and a self retaining retractor is also used to stretch the margins of the incision and maintain exposure during the osteotomy. An oscillating fan saw blade is used at right angle to the lateral calcaneal wall to perform the osteotomy. The medial wall of the calcaneus is carefully

Figure 3. Calcaneal osteotomy. The skin is retracted (a), the osteotomy performed and opened with a laminar spreader (b) and a guide pin inserted for a cannulated screw following 10 mm of medial displacement (c).

perforated with a slight punching action of the saw to prevent inadvertent soft tissue damage medially. After distraction of the osteotomy with a laminar spreader, a displacement of 10 to 12mm can be performed medially and fixation with either a cannulated screw or a locking plate can be performed (Figure 3).

Managing the muscle imbalance

This is the key to the success of the procedure and many changes have taken place in my own approach to the problem over the decades. With rupture of the PTT, there is always muscle imbalance due to weakness of inversion, and unbalanced activity of the peroneal musculature which of course produces increasing eversion. The PTT is the principle supinator of the subtalar joint along with functioning as an adductor of the midfoot and plantarflexor of the ankle[19]. So if this tendon is ruptured, we have to replace it with something else to balance the muscle forces of the hindfoot, but in doing so we should consider the strength of the transferred muscle. The FDL has only 28 % strength of the PTT and the FHL has 50 % strength of the PTT[20]. Although some surgeons have advocated transfer of the FHL instead of the FDL to replace the torn PTT, 100 % of patients report loss of FHL strength and we believe this is not an acceptable outcome. However, transfer of the FDL alone is also not adequate and the medial shift of the calcaneus with the MDCO does not ever compensate for this imbalance.

Although our earlier publications indicated that the results of this combination of treatment ie FDL transfer with MDCO was satisfactory, we now recognize that a transfer of the FDL is not the ideal procedure for correction of the balance of deformity. The FDL is far weaker than the PTT, and regardless of the additional procedures performed to improve the structure of the foot, the muscle imbalance remains. Therefore we have to do something else to increase inversion power or at the least, weaken the eversion power. The peroneus brevis acts as a deforming force in the flatfoot deformity and the unopposed pull of the peroneus brevis causes eventual elongation of the medial supporting structures, eventually leading to an abduction deformity. In the absence of a functioning PTT, the peroneus brevis therefore will always contribute to the worsening of the flatfoot deformity.therefore now recommend a transfer of the peroneus brevis tendon to the peroneus longus in conjunction with the FDL transfer, and the calcaneus osteotomy. By virtue of the insertion of the peroneus longus on the base of the 1st metatarsocuneiform joint the tendon transfer helps to strengthen the first metatarsal plantarflexion and reduces slightly the eversion of the hindfoot thereby improving the deformity correction. This can be performed through the same incision used for the calcaneal osteotomy by extending it slightly proximally and distally.

The next change in my practice, (we have to emphasize that this is our approach since this is not yet universally available nor accepted) over the recent years is to recognize that if the PTT is ruptured, the PT muscle may still however be functioning. To avoid the problems that I note above with the muscle imbalance, I prefer to use a tendon graft to replace the torn PTT instead of the FDL transfer. In this way, you are able to preserve the power of the posterior tibial muscle. It should be understood however that if the PTT graft procedure is used, then it should not be necessary to add a peroneus brevis to longus tenodesis. This procedure is discussed in more detail below.

Flexor digitorum longus (FDL) transfer surgical technique

A medial incision over the PTT is made and the tendon inspected to determine if just a debridement will be sufficient or whether an FDL transfer or tendon graft procedure is indicated, depending on the disease staging. It is not always easy to see the rupture of the PTT tendon, but by rotating the tendon the tear is seen since it is usually on the posterior surface of the tendon (Figure 4).

We transfer the FDL to the navicular by drilling through the bone with a 4.5 mm drill and passing the tendon through the intraosseous tunnel from plantar to dorsal. The tendon is then tensioned and sutured onto the periosteum both on the superior and undersurface of the navicular (Figure 5).

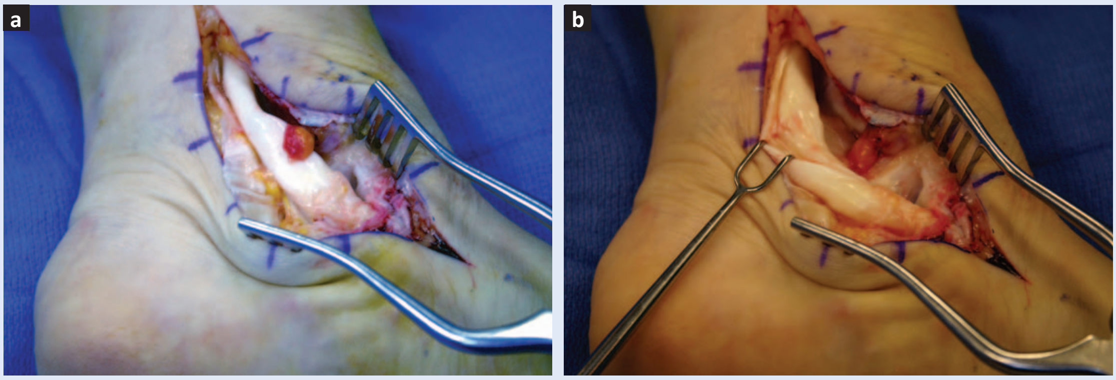

Figure 4. The tenosynovitis and the tearing and narrowing of the PTT (a). The rupture of the tendon is frequently visible on the posterior surface when rotating the tendon (b).

It is not necessary to use an interference screw, and this suture repair allows immediate weight bearing without concern for stretching. The tension that is set on the tendon during suture is important. The tendon must be tight, and although there are different opinions as to just how tight this transfer should be, my preference is to make the tendon as tight as possible without causing any subluxation at the medial malleolus. Some surgeons place the tendon tension half way between maximum and minimum tension which is a reasonable way to do this transfer.

Managing the spring ligament tear

The function of the spring ligament is to maintain the position of the talar head, forming the medial plantar sector of the articular cavity known as acetabulum pedis. The spring (calcaneo navicular) ligament, the deltoid ligament, the plantar ligaments and the plantar fascia in a passive way with the posterior tibial tendon in an active way, function to stabilize the subtalar joint and the medial longitudinal arch. It is essential that one always inspects the spring ligament complex during repair and reconstruction of the ruptured PTT. Furthermore, injury of the spring ligament can occur in isolation not associated with a tear of the PTT. While this isolated injury of the spring ligament is not common it does occur, and we have frequently made the error of assuming that a rupture of the PTT is present when it is the torn spring ligament that produces the exact same deformity of the hindfoot. The clinical diagnosis of this isolated tear is not easy, because the patient will have pain at the insertion of the PTT, but normal power and strength of the PTT is present. Eventually, rupture of the spring ligament will lead to a more vertically oriented talus.

Figure 5. The FDL is visualised passing from inferior to superiorly through the bony tunnel created in the navicular. It is sutured to the stump of the PTT and then dorsally to the periosteum over the navicular.

Historically, we attempted repair of the spring ligament with sutures, but these are rarely strong enough to support the repair. An alternative treatment is to place one suture anchor into the navicular and another into the sustentaculum tali and then use the sutures from the anchors to reinforce the repair of the ligament. As an alternative, we occasionally use a tendon graft which passes from the sustentaculum tali through a tunnel under the plantar medial head of the navicular to support the head of the talus. A 4.5 mm drill hole is made over a cannulated guide pin which is inserted 1cm under the sustentaculum. A lateral radiograph must be obtained to verify that it is not too close to the subtalar joint or the edge of the sustentaculum which can cause fracture. The 4.5 mm drill hole is then made and the allograft tendon is inserted into the hole with an interference screw or suture anchor holding the position securely. The second hole is made from the plantar medial inferior pole of the navicular aiming dorsally out the center of the navicular. The tendon is then pulled through and an interference screw is inserted under the navicular to maintain maximum tension. The tension is set with the foot in slight varus at the talonavicular joint. If this procedure is performed in conjunction with an FDL transfer then one has to be careful with the drill tunnels in the navicular to prevent fracture.

As mentioned previously the FDL is a weaker muscle, therefore we adopt certain techniques which would help to augment the power of the transfer. Firstly as described earlier, a peroneus brevis to longus tenodesis is performed after the calcaneal osteotomy (Figure 6-7).

Allograft reconstruction of the PTT

As mentioned previously, because both the FDL and FHL are weaker than the PTT muscle we have recently started to consider ways of salvaging the PTT and using its inherent power to recreate the medial arch. An FDL transfer into the navicular combined with a more proximal tenodesis to the PTT could take advantage of the strength of the posterior tibial muscle to contribute to the functional transfer of the FDL. However, there are problems with this tenodesis procedure. Firstly, the torn PTT cannot or should not be routinely used since there may be no functioning muscle, the result of chronic rupture resulting in fatty infiltration of the muscle and permanent loss of

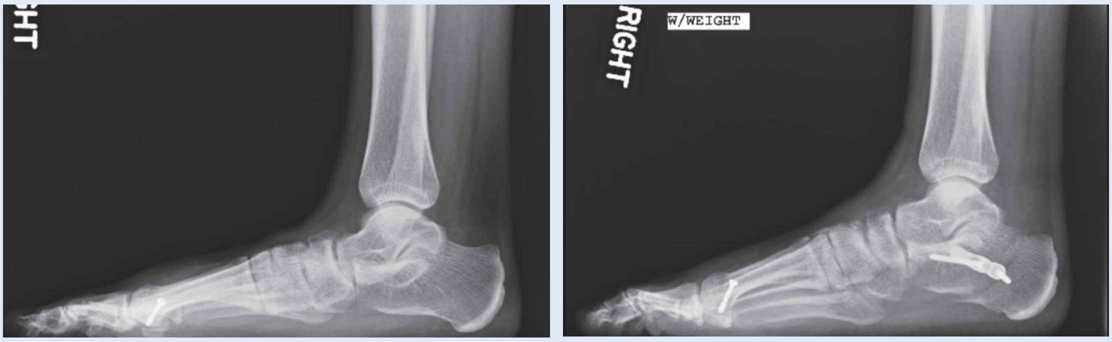

Figure 6. Radiographic appearance before and after reconstruction with a spring ligament repair. In this case, there was a rupture of the spring ligament with an associated flatfoot but the PTT was quite normal with no tenosynovitis nor rupture.

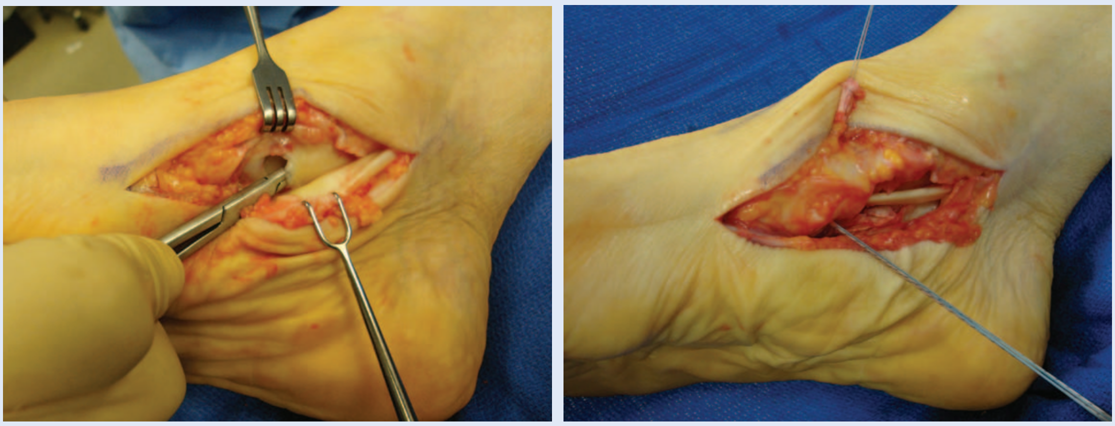

Figure 7. An example of a rupture of the PTT as well as a defect in the spring ligament. The FDL tendon was transferred, and a suture anchor inserted under the navicular and then a second suture anchor into the sustentaculum.

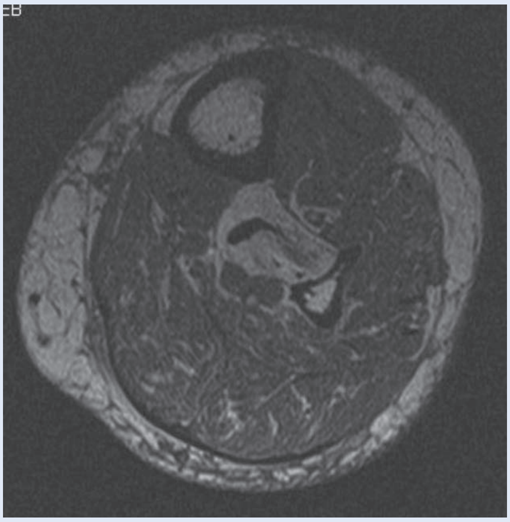

Figure 8. The fatty atrophy of the PT muscle. This is a contraindication to performing an allograft tendon reconstruction.

function (Figure 8). Secondly, even if the muscle appears healthy on MRI, due to chronic scarring, there may be no excursion of the tendon behind the ankle due to fibrosis and adhesions of the tendon to the surrounding tissue regardless of the health of the PT muscle. Thirdly, the excursion of the FDL is greater than the PTT in both flexion/extension and inversion/eversion, and it is therefore difficult to match the tension when tenodesis is performed between the two tendons. The problem here, as has been discussed in the past, is, what is the ideal tension for the FDL transfer? Should this be at maximum tension to take advantage of the ability of the tendon to then correct the deformity? The assumption with this approach to the transfer is that regardless of how and where the elongation occurs, the transfer always stretches out and therefore it makes no difference how much the FDL is tensioned. Finally, it has been reported that whether a side to side tenodesis of the PTT to the FDL is performed proximally, the clinical outcome remains similar.

Patients with a flexible flatfoot deformity and posterior tibial tendon rupture are candidates for allograft reconstruction provided they have adequate posterior tibial muscle and excursion at the musculotendinous junction. We therefore routinely assess the viability of the PTT muscle preoperatively with MRI, however excursion of the PTT can only be adequately assessed intra-operatively. This procedure should be done in association with appropriate osteotomies to correct the deformity as needed according to the deformity. We obtain a MRI of the leg (not the ankle) routinely for all patients who are candidates for allograft reconstruction in order to evaluate for fatty atrophy of the muscle. Before commencing with the planned allograft reconstruction, if still present, the excursion of the PTT is assessed and if inadequate or stuck, the allograft reconstruction is stopped and an FDL transfer performed.

Managing the muscle imbalance is the key to the success of the procedure and many changes have taken place in my own approach to the problem over the decades.

There are two incisions made for the allograft procedure. The first is a distal incision which exposes the torn PTT and the navicular and the second is more proximally at the musculotendinous junction of the PTT. In this way, the flexor retinaculum is kept intact, and the allograft, once attached proximally to the PTT, it can be easily passed through the navicular as for the FDL transfer. The diseased portion of the PTT is excised starting 6 cm distal to the musculoskeletal junction and leaving a distal stump of the PTT attached to the navicular. This distal stump will be necessary after graft passage to provide more substance for distal graft attachment. The tendon distal to the musculoskeletal junction is preserved for fixation of the proximal graft.

A whipstitch is passed through both ends of the allograft. The graft is passed through the PTT sheath after excising the appropriate length of the PTT and secured to the proximal PTT stump using a tendon weave suture. It may now be sutured to the tendon before it enters the navicular tunnel, the surrounding periosteum and the distal PTT stump with a #0 non absorbable suture. The portion of the tendon that will be attached distally is sized and a 4.5 mm cannulated drill is drilled over a guide pin placed at the junction of the medial one-third and lateral two-thirds of the navicular. The passed tendon is laid down medially onto the plantar limb of the tendon and the

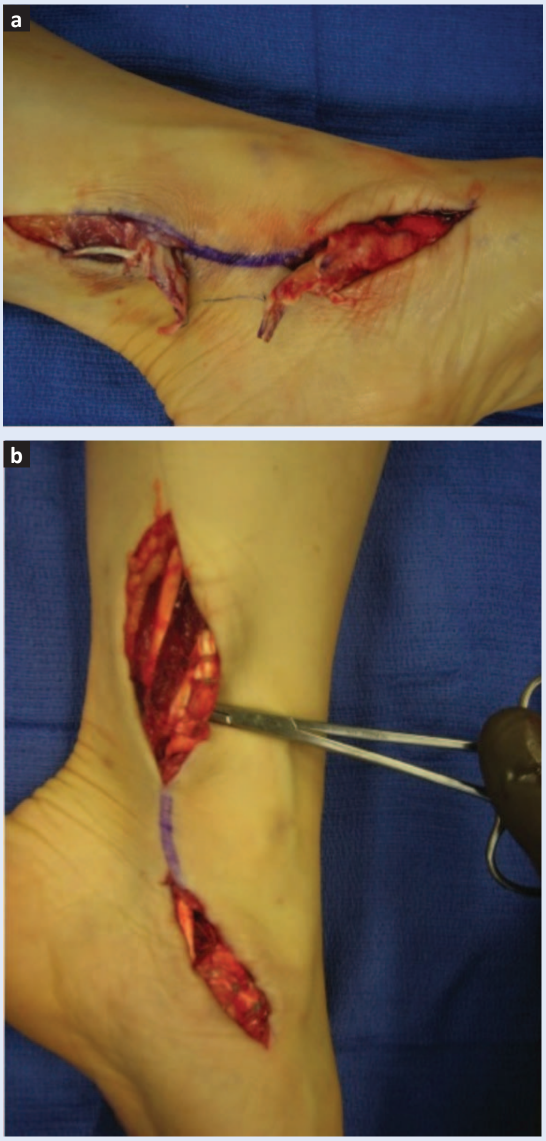

Figure 9. a) Representation of the two incisions used. Note the stump of the PTT distally which is preserved with its attachment to the navicular. This is used to reinforce the repair of the allograft when attached to the navicular through the bony tunnel. b) The proximal stump is preserved to Pulvertaft to the allograft as shown in the figure on the right.

distal PTT stump. Figure 9 shows the intra operative pictures of this technique and demonstrates the incisions used. As noted above in the discussion of the FDL transfer, the optimal tension for the tendon graft is still not clear. While it may make sense to suture the graft into the PTT at its resting tension, the excursion of the PTT is so short that it is our practice is to tighten the transfer such that the foot is in 10 degrees of varus at the completion of the transfer.

Following the allograft procedure, the patient is placed in a boot with an inverted heel wedge and is not permitted to bear weight. At two weeks post operatively, they are allowed to begin passive and active dorsiflexion and plantarflexion with physical therapy. They are allowed to partially weight bear at two weeks and fully weight bear at the six week stage. They are then transitioned into a supportive ankle brace in a comfortable lace up or running shoe for an additional six weeks. Physical therapy emphasizing strengthening and balance is begun at six weeks and continued for two to three months when the patient is able to continue the rehabilitation program without assistance.

ADDITIONAL PROCEDURES

It is important to understand that there is an incredible variation in the pathology of the adult painful flatfoot deformity. In this manuscript we have focused mainly on the calcaneus osteotomy and the muscle balancing procedures. This does not do justice to the many additional procedures that are however required as part of the flatfoot correction which is determined by the different stages of deformity as outlined above. For example, a lateral column lengthening osteotomy whether at the neck of the calcaneus or at the calcaneocuboid joint has not been discussed, but is performed when the midfoot is abducted over the talus, and there is more than 35 % uncovering of the talonavicular joint by the navicular[14]. Our preference is to perform this lengthening at the neck of the calcaneus, 1cm proximal to the calcaneocuboid joint. A MDCO of the calcaneus is not able to correct abduction of the transverse tarsal joint since the apex of the deformity that is corrected with this translational osteotomy is the subtalar joint. Therefore a lateral column lengthening procedure must be considered. The procedure is performed by retracting the peroneal tendons and marking the osteotomy with a K-wire 1 cm proximal to the joint (Figure 10). The osteotomy is made with a saw, cutting the width of the calcaneus from lateral to medial, it is then distracted, and the size of the graft determined under fluoroscopy to ensure that good coverage of the talonavicular joint has been obtained. This

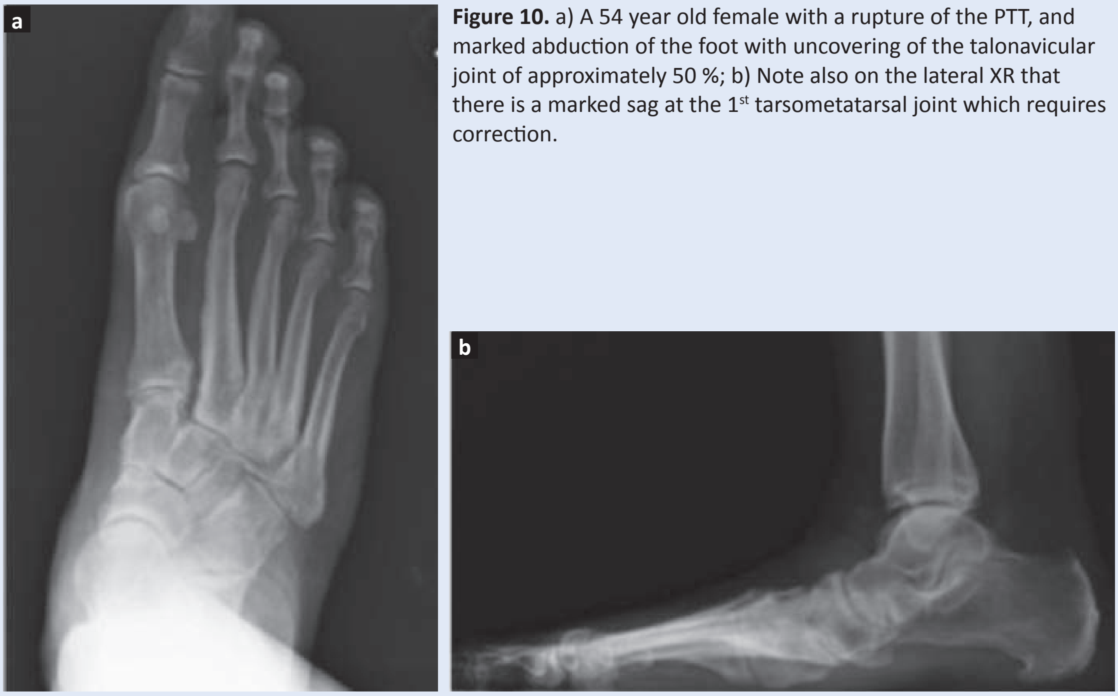

Figure 10. a) A 54 year old female with a rupture of the PTT, and marked abduction of the foot with uncovering of the talonavicular joint of approximately 50 %; b) Note also on the lateral XR that there is a marked sag at the 1st tarsometatarsal joint which requires correction.

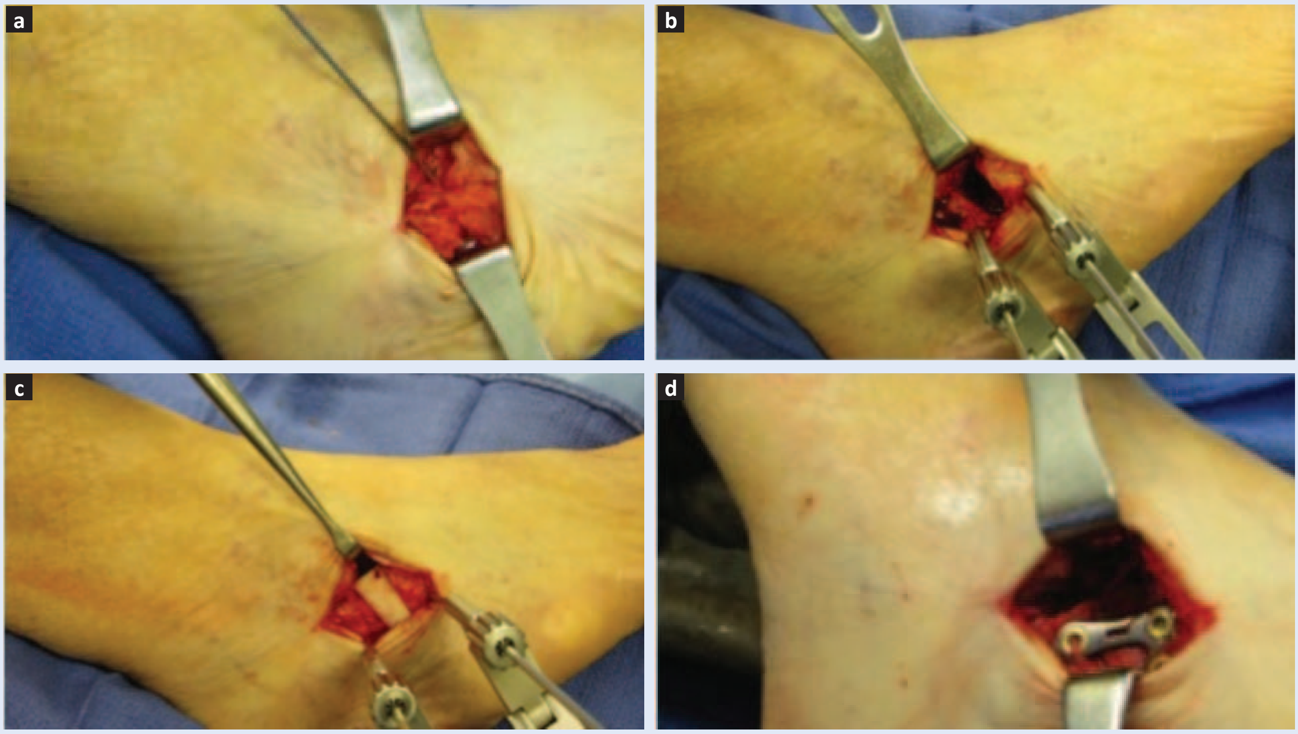

Figure 11. a) The osteotomy for the lateral column lengthening is made 1 cm proximal to the calcaneocuboid joint and the location is marked with a K-wire to guide the axis of the osteotomy; b) The osteotomy is made with a saw, and then distracted approximately 8-10 mm using a specific pin distractor (Paragon 28, Denver Colorado). Note the biplanar opening of the osteotomy, slightly wider dorsally and laterally; c) The graft is inserted and the pin distractor removed; d) The osteotomy is secured with a specific plate designed for a lateral column lengthening (Paragon 28, Denver Colorado).

is attained using a pin distractor specifically designed for this procedure (Figure 11). In selected cases the peroneus brevis tendon is then transferred to the peroneus longus tendon to decrease the abduction and eversion force on the hindfoot (Figure 12).

Figure 12. Due to the severity of the abduction deformity, the peroneus brevis tendon was transferred to the peroneus longus tendon.

We are now performing an opening wedge osteotomy of the medial cuneiform almost routinely (the Cotton procedure), even for cases where the forefoot supination is minimal. Although this is not done strictly according to our classification above, the addition of this osteotomy seems to improve the alignment of all the feet irrespective of the extent of forefoot supination. In addition, we have noted that by using the cuneiform osteotomy, there is far less need for an arthrodesis of either the 1st tarsometatarsal joint or the naviculocuneiform joint. The cuneiform osteotomy increases the tension on the windlass mechanism, and in doing so the radiographic instability at the adjacent joints improves.

Conflicts of interest statement: The authors report no conflicts of interest.

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