Split Anterior Tibialis Tendon Transfer for Treatment of Equinovarus in Cerebral Palsy

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Abstract

Background: Individuals with severe varus feet often have the appearance of severe untreated clubfeet and when treatment is desired often require very extensive decompression. Because of the large magnitude of the surgery, caretakers should be offered the options of making well-padded protective orthotics and using wheelchair protective foot buckets instead of footrests. An equinovarus deformity renders the foot and ankle in an unsuitable posture for gaiting, wearing shoes and bracing, as well as resulting in formations of callosities. This deformity is attributed to the imbalance of the ankle invertor, including the anterior tibialis (AT), posterior tibialis (PT) and evertor muscles. A combination of a split tibialis anterior or tibilais posterior transfer of the tendon and lengthening of the ankle plantar flexor muscles have been proposed to position the plantigrade foot. Biomechanically, split tibilais anterior tendon transfer is an appealing procedure. The function of the tibilais anterior is to maintain the neutral position when the hindfoot is corrected and therefore many authors prefer the split tibilais anterior tendon transfer procedure.

Keywords: Split anterior tibialis tendon transfer, Equinovarus, Cerebral Palsy

Introduction

The radiographic angles provide poor correlation to specific deformity, have poor accuracy, and are very position dependent. (1).

The radiographic indices calculated were lateral tibiocalcaneal angle, lateral talocalcaneal angle in lateral view and talo-1st metatarsal angle in antero-posterior view **(2).**

Decades ago, many authors questioned whether radiographic appearances of the foot bore any relationship to clinical outcome. The literature includes numerous papers in which there is no correlation between radiographic parameters and clinical outcome. The most commonly measured radiographic parameter quoted in assessment of outcome is talocalcaneal angle (TCA) **(3).**

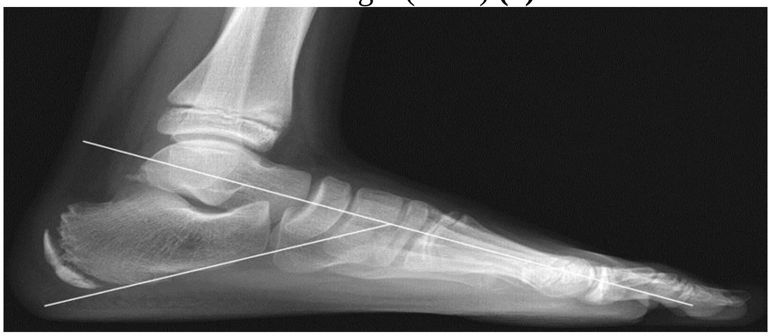

Figure (1): X-ray lateral view shows Talocalcaneal angle-lateral (TCA-LAT) **(2).**

Figure (2): Standing lateral radiograph of an equinovarus left foot, showing the tibiocalcaneal angle **(2).**

Figure (3): Left foot DP X-ray shows talo-1st metatarsal angle in a child with equinovarus deformity **(4).**

Treatment of cerebral palsy takes an interprofessional team approach. The team includes physicians (primary care, neurologists, physiatrists, orthopedists, and other specialists needed based on co-existing conditions), therapists (physical, occupational, and speech), behavioral health specialists, social workers/case managers, and educational specialists. Interventions should focus on maximizing the quality of life and decreasing the disability burden. The patient, family, and team should set functional goals that are realistic and periodically reevaluated **(1).**

Oral and injectable (e.g., botulinum toxin) medications can help to treat tone abnormalities, pain, and comorbid conditions such as epilepsy, sialorrhea, gastrointestinal disturbances, and behavior disorders. Medications used for spasticity include benzodiazepines, baclofen, dantrolene, tizanidine, cyclobenzaprine, botulinum toxin, and phenol **(35).**

Clinicians often treat dystonia with trihexyphenidyl, gabapentin, carbidopa-levodopa, and benztropine. Sialorrhea treatment includes glycopyrrolate, atropine drops, and scopolamine patches. Anti-seizure medications are used in patients with epilepsy. Constipation is a frequent complication of cerebral palsy, requiring stool softeners and pro-motility agents **(1).**

Anti-inflammatories address pain and antidepressants for depression and anxiety. Surgical management options include placement of a baclofen pump, selective dorsal rhizotomy, tendon releases, hip derotation/rotation surgery, spinal fusion, strabismus repair, and deep brain stimulation **(5).**

Treatment of equinovarus in cerebral palsy:

Children with equinovarus feet secondary to CP tend for the deformity to evolve during growth. Under age 8 years, treatment should focus the use of orthotics and addressing the primary equinus contracture. After age 8 years, based on a full gait analysis, split transfer of the tibialis posterior to the perineus brevis is often useful **(6).**

If the tibialis anterior is the most deforming force, a split transfer to the perineus longus with or without mild lengthening of the tibialis posterior is a good option. Recurrent deformities are best managed with calcaneal osteotomy or calcaneocuboid joint resection and fusion. The major unrecognized long-term complication of treatment is over correction into planovalgus **(7).**

<u>Indications:</u>

The supple foot deformity commonly seen in early and middle childhood is best treated with an orthotic. If there is a significant component of equinus with the varus, a full calf height AFO is required. For rare children, usually those in whom the gastrocnemius has been lengthened and some residual varus remains in stance phase, the use of a supramalleolar orthotic with a lateral heel post may control the foot **(8).**

Recently there have been reports of improvement in the equinovarus position after botulinum toxin injection into the tibialis posterior. It is not clear if this treatment has any long-term benefit; however, it may also be a diagnostic therapeutic tool. Often, when children are having an evaluation for surgical reconstruction to improve gait, usually at 5–7 years of age, the foot has an element of varus, especially when they are standing on tip toes **(9).**

A full examination should include an EMG of the tibialis posterior using a fine wire; however, many children at this age are not able to cooperate to have the wire inserted and then walk with a normal gait pattern. Also, at this age in children with diplegia, usually no surgery should be performed to correct varus deformity unless the varus is severe and there is an already fixed contracture of the tibialis posterior**(10).**

An extremely high number of children with supple varus will fall into valgus gradually as adolescence approaches, and any surgery on the tibialis anterior or tibialis posterior will often only exacerbate the natural history. Valgus foot collapse is an extremely strong attractor for ambulatory children with diplegia who enter adolescence, and all early treatment has to consider the strength of this attractor **(8).**

For children with hemiplegia who have severe varus foot position with any degree of tibialis posterior contracture, consideration of mild intramuscular lengthening of the tibialis posterior is recommended. In early and middle childhood, varus foot deformities should be left alone unless they are severe with at least some fixed muscle contracture, meaning there is some limitation in hindfoot and forefoot varus when these children are completely relaxed **(6).**

<u>Adolescents:</u>

By the preadolescent or adolescent age of 8–12 years, children with a varus foot deformity will develop much more defined deformity, often becoming symptomatic from pain due to high pressure over the lateral fifth metatarsal. At this age, the risk of over correction into valgus is also reduced. By this age, most children will be able to cooperate for a full EMG evaluation, which includes an EMG fine wire of the tibialis posterior **(9).**

If the child can cooperate to have the wire in the tibialis posterior, then it does not impact the gait pattern. If the tibialis posterior has no contracture, which means easy overcorrection of the hindfoot is possible, and the EMG shows this muscle to be active throughout stance phase or constantly active, a split transfer to the lateral side with attachment to the peroneus brevis is recommended **(7).**

There is also one report suggesting comparing of the timing of the perineus longus is also predictive of better outcome when it is normal. Children in this age group with varus foot deformities that can be manually corrected to at least a neutral heel are ideal candidates for correction by tendon surgery. If the varus is most significant during swing phase and the tibialis anterior is on constantly or on during the majority of stance phase, a split transfer of the tibialis anterior is performed with attachment to the cuboid or a slip of the peroneus longus **(8).**

If both muscles are constantly active, both can be split-transferred, especially if there is a severe deformity. If the tibialis anterior is constantly active and the tibialis posterior has a contracture, the tibialis posterior may have a myofascial lengthening and the tibialis anterior a split transfer. The equinus must be addressed based on the degree of dorsiflexion on the kinematics and physical examination **(11).**

After the surgical correction in the operating room, the foot should rest in neutral to slight valgus. If the foot rests in varus after the tendons are attached in surgery, final correction of the varus is very unlikely. Following the tendon transfer, children are immobilized in a weight-bearing cast with slight overcorrection into valgus and at neutral to 5° of dorsiflexion. This cast is maintained for 4 weeks, after which the children are allowed full activity without orthotic control **(9).**

<u>Fixed Heel Varus:</u>

Children with fixed heel varus, which cannot be passively corrected, are usually well into adolescence or are young adults, typically ages 15–20 years. This group includes failures of tendon transfers and children who were medically neglected and did not receive surgery at an earlier age when tendon surgery would have sufficed. Because of the fixed deformity, the treatment often requires an osteotomy **(12).**

If the primary problem is a fixed hindfoot varus, correction by Dwyer sliding and closing wedge calcaneal osteotomy is recommended. If the primary deformity is midfoot, then excision of the calcaneocuboid joint is recommended. This lateral closing wedge osteotomy will improve some hindfoot varus as well; however, in rare severe cases, both the Dwyer calcaneal osteotomy and the lateral calcaneocuboid joint resection fusion may be needed **(8).**

Along with the bone osteotomy, a Z-lengthening of the tibialis posterior is recommended. Because of severe shortening and the long tendon, it is more difficult to find adequate muscle mass to do a myofascial lengthening in individuals with this level of severity of tibialis posterior contracture. The osteotomy should be fixed with internal fixation, and again, the amount of correction will never be better than that seen in the operating room at the conclusion of the procedure **(10).**

Many of these individuals also have a very prominent fifth metatarsal from longtime weight bearing. The appearance of the foot and the immediate comfort of the individuals will often be improved if this overgrowth is resected. Immobilization in a cast is usually required for 8 weeks to allow full bone healing. Weight bearing is allowed as soon as tolerated from the perspective of pain **(11).**

<u>Severe fixed spastic varus feet:</u>

Individuals with severe varus feet often have the appearance of severe untreated clubfeet and when treatment is desired often require very extensive decompression. Because of the large magnitude of the surgery, caretakers should be offered the options of making well-padded protective orthotics and using wheelchair protective foot buckets instead of footrests **(9).**

However, the main complaint is usually skin breakdown from footrests while individuals are in the wheelchair. If surgical correction is desired, a choice has to be made between a triple arthrodesis and a talectomy. If there is some mobility in the foot that allows substantial correction under anesthesia, a triple arthrodesis can be performed with a tenotomy of the tibialis posterior at the level of the medial malleolus **(8).**

Most of the severe deformities are very stiff, and a talectomy is a simpler procedure that allows excellent correction. All these deformities that we treated have occurred in nonambulatory children in whom the symptomatic problem was skin breakdown over the feet as they grew to adult size **(6).**

Along with the talectomy, all the muscles are tenotomized, including the tendon Achilles, tibialis anterior, tibialis posterior, and peroneus brevis and longus. Both talectomy and triple arthrodesis provide stable long-term correction of the deformity in this group of individuals with limited demands on the feet **(7).**

Other treatments:

There have been other operative procedures reported to treat varus foot deformity in addition to those presented. Complete transfer of the tibialis posterior through the interosseous membrane to the anterior aspect of the foot was recommended by some authors. This transfer was suggested to assist with dorsiflexion, similar to its use in feet with paralysis. This transfer should never be used in spastic feet because it causes the worst deformed feet over time that we have ever seen **(11).**

Most of these feet require triple arthrodesis in a very technically demanding procedure. There are a few children in whom the posterior tibialis muscle activity on EMG seems to have completely changed phase to match the tibialis anterior. These feet are theoretically ideal candidates for complete anterior transfer of the tibialis posterior **(8).**

Transposing the tibialis posterior around the medial side of the tibia by moving it anterior to the medial malleolus has been advocated as well; however, this leads to a high number of severe cavus foot deformities, which again are harder to treat than the initial deformity. This procedure is not recommended in children with varus deformities secondary to spasticity **(10).**

Split transfer through the interosseous membrane of half of the tibialis posterior has been recommended for use in children in whom the tibialis posterior is constantly active and for children who have significant varus in swing phase. However, it seems to have a relatively narrow indication, and it is not clear that there are real advantages over the standard lateral transfer, which is technically easier **(7).**

Anterior transfer of the long toe flexors has been advocated as a way of balancing the foot with spastic varus however, it seems to be using muscles with extremely small force potential and is not theoretically sound on that basis **(8).**

Split anterior tibialis tendon transfer (SPLATT):

An equinovarus deformity renders the foot and ankle in an unsuitable posture for gaiting, wearing shoes and bracing, as well as resulting in formations of callosities. This deformity is attributed to the imbalance of the ankle invertor, including the anterior tibialis (AT), posterior tibialis (PT) and evertor muscles **(2).**

A combination of a split tibialis anterior or tibilais posterior transfer of the tendon and lengthening of the ankle plantar flexor muscles have been proposed to position the plantigrade foot. Biomechanically, split tibilais anterior tendon transfer is an appealing procedure. The function of the tibilais anterior is to maintain the neutral position when the hindfoot is corrected and therefore many authors prefer the split tibilais anterior tendon transfer procedure **(13).**

Indications:

The indications for the SPLATT procedure are identified by an equinovarus deformity of the foot with a prominent AT tendon when gaiting and a positive flexor withdrawal reflex test (confusion test) for AT overactivity, and the deformity could not be controlled by conservative measures **(11).**

Technique:

The procedure is done under general anaesthesia and the patients are operated on standard radiolucent operation table. A longitudinal incision is made, lying over the medial border of the foot for release of the half on the anterior tibialis tendon. The split tendon is harvested via an anterior approach above the ankle by opening the anterior tibial tendon sheath. The medial approach is then closed. A lateral incision is made to expose the peroneus brevis tendon, the split tibialis anterior tendon is sutured to the peroneus brevis with gastrocnemius recession and fractional lenghthening of tibilais posterior tendon **(13).**

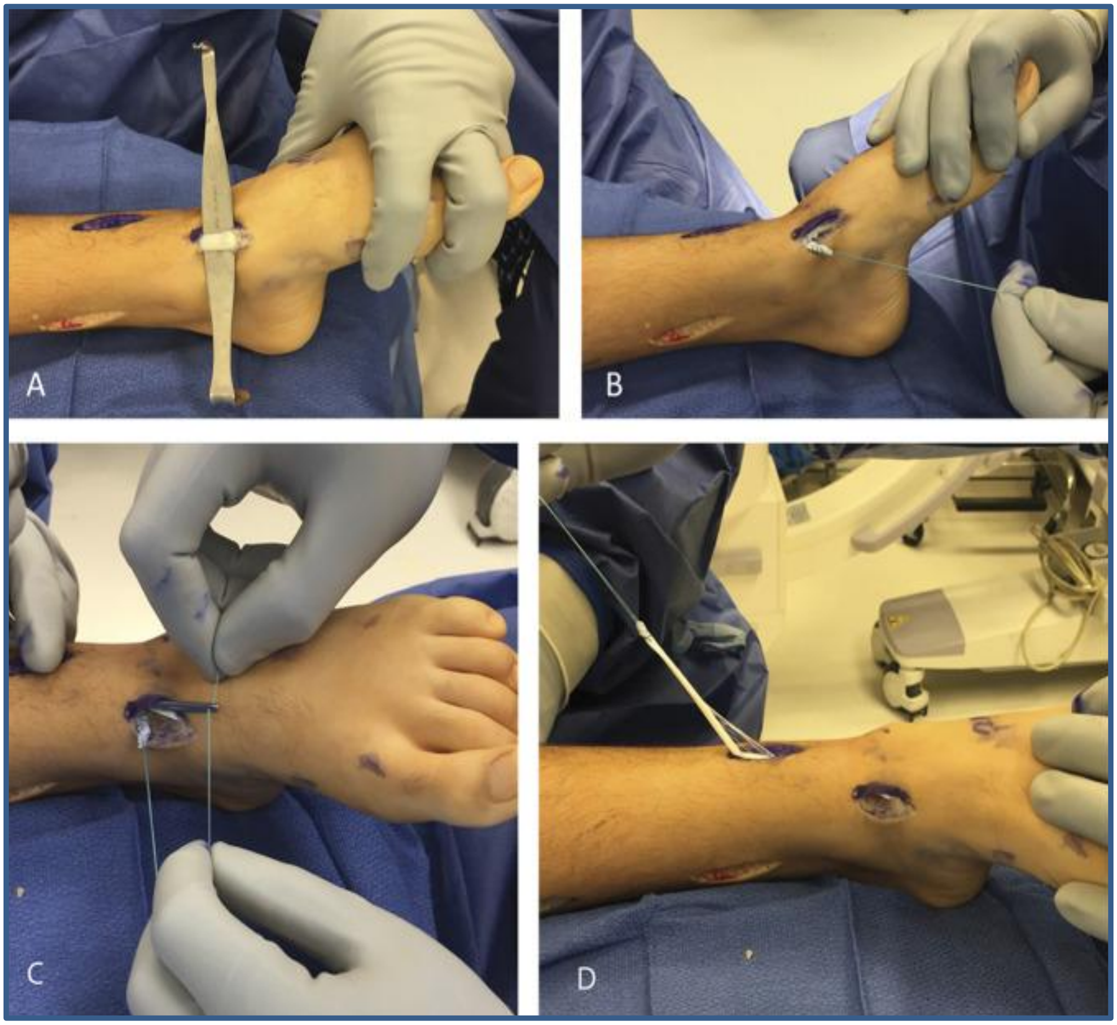

Figure (4): Photograph showing the anterior tibial tendon harvesting and splitting. A, Anterior tibialis tendon identified at the distal, medial incision; (B) Plantar half of the tendon is harvested and a nonabsorbable 2-0 whip stitch is placed through the distal stump; (C) An Ober tendon passer passed through lower leg incision (deep to extensor retinaculum) and the whip stitch retrieved; (D) The tendon splits longitudinally as the suture is retrieved **(7).**

Complications:

These fall into the following three groups; undercorrection, overcorrection and recurrence of deformity **(6).**

- <u>Undercorrection:</u>

This may occur following any method of treatment and may be due to error in application, or failure of a particular technique. This is more likely in the more difficult teratological feet. Undercorrection of deformity following soft tissue surgery presents a challenge. Further releases are more difficult due to the presence of scar tissue, and inevitably one would expect a degree of stiffness following redo surgery. The circular frame is a powerful tool in achieving progressive correction of deformity with minimal surgical release and may be helpful following failed surgical release **(14).**

- Overcorrection:

Some of the poorest results are due to overcorrection. This is a very difficult situation to treat. Overlengthening of the tendo Achilles, with or without tibialis posterior overlengthening, may produce a calcaneus deformity, which may be associated with valgus **(13).**

- Recurrence of deformity:

The problem of deformity recurrence exists with all methods of treatment. The most common cause of recurrent deformity is failure to wear the boots and bar. If recurrent deformity has not occurred by 5 years of age, it is not likely to do so. The current recommendations are that most children wear the boots and bar at sleep times until 4 years of age **(14).**

Recurrent deformity may occur following surgical releases. Scarring of the foot from previous surgery makes it more difficult to correct the deformity with remanipulation and recasting, although there is a place for this in some feet. Further soft tissue releases can be undertaken, but if there is already extensive scarring then it may be difficult to achieve the required correction, and this can therefore be unrewarding. Bony procedures may become necessary **(11).**

The surgery indicated will depend upon the site of deformity and its nature. It may be in the hind-, mid- or forefoot. The heel may be in equinus, with or without varus, and this can be corrected with calcaneal osteotomy. Again, correction may be undertaken using the circular frame, along with osteotomies, depending upon the age of the child. A muscle balancing procedure such as tibialis anterior tendon transfer may still be necessary in order to prevent further recurrence **(15).**

- **Outcome:**

Decades ago, many authors questioned whether radiographic appearances of the foot bore any relationship to clinical outcome. The literature includes numerous papers in which there is no correlation between radiographic parameters and clinical outcome. The most commonly measured radiographic parameter quoted in assessment of outcome is talocalcaneal angle (TCA) **(3).**

There is still no single, easy to use, recognized outcome tool that is in widespread use. This makes comparison of different methods of treatment difficult. There are numerous studies that re-evaluate the outcome of treatment before skeletal maturity and are quoting long-term results, but a paucity of studies after skeletal maturity **(7).**

Most studies have a follow-up in the order of 10 years. Deteriorating results have been shown in papers quoting longer follow-up. There is a need for good prospective long-term outcome studies that can be used to compare different methods of treatment **(16).**

References

1. **Noh, H., & Park, S. S. (2013).** Predictive factors for residual equinovarus deformity following Ponseti treatment and percutaneous Achilles tenotomy for idiopathic clubfoot: a retrospective review of 50 cases followed for median 2 years. Acta Orthopaedica, 84(2), 213-217.
2. **Wong, P., Fransch, S., Gallagher, C., Francis, K. L., Khot, A., Rutz, E., & Graham, H. K. (2021).** Split anterior tibialis tendon transfer to peroneus brevis for spastic equinovarus in children with hemiplegia. Journal of Children's Orthopaedics, 15(3), 279-290.
3. **Gjonej, A., Gjonej, R., Selmani, E., & Çaushi, G. (2014).** Results of Clubfoot Treatment with Kite Method. International Journal of Orthopaedics, 1(3), 116-119.
4. **Hadi, M. H., Nurein, M. A., Bader, M. A. E. S., Salih, M. M. A., & Babikir, H. E. (2019).** Radiological study of anatomical bony arrangement of the clubfoot deformity and its correlation with the Pirani clinical scoring system: A multicenter study. Sudanese Journal of Paediatrics, 19(2), 101.
5. **Bekteshi, S., Monbaliu, E., McIntyre, S., Saloojee, G., Hilberink, S. R., Tatishvili, N., & Dan, B. (2023).** Towards functional improvement of motor disorders associated with cerebral palsy. The Lancet Neurology.
6. **Picelli, A., Di Censo, R., Zadra, A., Faccioli, S., Smania, N., & Filippetti, M. (2023).** Management Of Spastic Equinovarus Foot in Children with Cerebral Palsy: An Evaluation of Anatomical Landmarks for Selective Nerve Blocks of the Tibial Nerve Motor Branches. Journal of Rehabilitation Medicine, 55, jrm00370-jrm00370.
7. **Lullo, B., Nazareth, A., Rethlefsen, S., Illingworth, K. D., Abousamra, O., & Kay, R. M. (2020).** Split tibialis anterior tendon transfer to the peroneus brevis or tertius for the treatment of varus foot deformities in children with static encephalopathy: a retrospective case series. JAAOS Global Research & Reviews, 4(5).
8. **Miller, F. (2020).** Equinovarus Foot Deformity in Cerebral Palsy. In: Miller, F., Bachrach, S., Lennon, N., O'Neil, M.E. (eds) Cerebral Palsy. Springer, Cham.
9. **Dussa, C. U., Böhm, H., Döderlein, L., & Fujak, A. (2022).** Treatment of spastic varus/equinovarus foot with split-tendon transfers in cerebral palsy: How does it affect the hindfoot motion?. Gait & Posture, 92, 343-350.
10. **Limpaphayom, N., Chantarasongsuk, B., Osateerakun, P., & Prasongchin, P. (2015). The** split anterior tibialis tendon transfer procedure for spastic equinovarus foot in children with cerebral palsy: results and factors associated with a failed outcome. International orthopaedics, 39, 1593-1598.
11. **Chowdhury, S. (2022).** Split anterior tibial tendon transfer (Splatt) to the peroneus brevis/tertius for the correction of varus foot deformity in children: A case series. International Journal of Orthopaedics, 8(4), 16-20.
12. **Krzak, J. J. (2013).** Equinovarus in Cerebral Palsy (Doctoral dissertation, University of Illinois at Chicago).
13. **Sarıkaya İA, Birsel SE, Şeker A, Erdal OA, Görgün B, İnan M.** The split transfer of tibialis anterior tendon to peroneus tertius tendon for equinovarus foot in children with cerebral palsy. Acta Orthop Traumatol Turc. 2020 May;54(3):262-268.
14. **Deltombe, T., Gilliaux, M., Peret, F., Leeuwerck, M., Wautier, D., Hanson, P., & Gustin, T. (2018).** Effect of the neuro-orthopedic surgery for spastic equinovarus foot after stroke: a prospective longitudinal study based on a goal-centered approach. Eur J Phys Rehabil Med, 54(6), 853-859.
15. **Allart, É., Sturbois-Nachef, N., Salga, M., Rosselin, C., Gatin, L., & Genêt, F. (2021**). Neuro-orthopedic surgery for equinovarus foot deformity in adults: a narrative review. The Journal of Foot and Ankle Surgery.
16. **Keenan, M. A. (2011).** The management of spastic equinovarus deformity following stroke and head injury. Foot and ankle clinics, 16(3), 499-514