Acta Orthop Traumatol Turc 29, 339-341, 1995

The biomechanics and surgical reconstruction of talipes equinovalgus & cavovarus deformations

(Cavovarus ve talipes equinovalgus deformitelerinin cerrahi rekonstrüksiyonu ve biyomekaniği)

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Talipes equinovalgus ve kavovarus birbirinin tersi olan deformitelerdir. Normal bir ayakta stans fazında talusun 10 derece dorsifleksiyon yapması gereklidir. Aşil tendonundaki kısalık nedeni ile bu mümkün değil ise midtarsal eklemden ayak çöker. Peroneus longus birinci metatarsı kontrol edemez ve tarsal eklemlerde instabilite oluşur. Talusun mediale yer değiştirmesi ile ayakta pronasyon gelişir. Kavovarus deformitesinde ise tam tersine talus dorsifleksiyonda ve lateraldedir. Bunun sonucunda ayağın arka kısmı inverte olur, ön kısmi ise adduksiyon ve mediale yer değiştirir. Bu farklılıklar nedeni ile pes equinovalgusda aşil tendonu uzatması gerekli iken cavovarusda bu işleme gerek yoktur. Equinovalgusda tibial adelelerden bir veya ikisinde paralizi var ise subtalar veya talonaviküler artrodeze de gereksinim olmaktadır. Tripl artrodez eklem dejenerasyonu var ise uygulanmalıdır. Paralizi yok ise kalkaneal osteotomiler uygulanmalıdır. Bu prosedüre ek olarak tibialis anteriorun navikülaya transferi ve küneiform osteotomisi uygulanabilir. Talipes kavovarus genellikle nöromüsküler hastalıklara sekonder geliştiğinden erken yaşlarda tendon transferine gereksinim vardır. Bunların arasında en sık posterior tibial tendonun ayak sırtına transferi kullanılmaktadır. Bunun dışında plantar fasyatomi, Dwyer osteotomisi ve parmaklardaki deformitelere yönelik girişimler yapılabilir.

Anahtar kelimeler: *Talipes equinovalgus deformitesi, kavovarus deformitesi, cerrahi rekonstrüksiyon, biyomekanik*
(Talipes equinovalgus deformity, talipes cavovarus deformity, surgical reconstruction, biomechanics)

Talipes equinovalgus & cavovarus are virtual opposite deformities. They are mirror reflections of each other. The biomechanics and surgical reconstructions concepts are also opposite.

Foot & Ankle Biomechanical Function:

The interaction of the foot & ankle with the knee and hip is intimate (1, 2, 3). The phasic muscle activity of the extrinsic leg muscles has an important contribution to the manner in which the foot functions in stance phase of gait. The talus must be able to dorsiflex at least 10 degrees in the ankle mortise during stance phase of gait. This is commonly referred to as "ankle dorsiflexion". After "heel contact" phase of gait, the tibia moves forward over the dome of the talus as the tibia and fibula rotate medial during the early portion of stance phase of gait. This allows the foot to pronate and be a mobile adaptor to uneven terraine (3, 4, 5). If the heel cord or triceps surae is short. the required 10 degrees of dorsiflexion cannot be achieved; and the foot will collapse the mid foot level in order to compensate and obtain the additional dorsiflexion. The peroneus longus muscle/tendon will not be able to stabilize the mid tarsal joint and the first metatarsal bone will elevate causing tarsal joint instability (5). This is the method of compensation when equinus is present. Thus, the surgeon must carefully examine the foot and ankle to make certain the talus is actually dorsiflexing in the ankle, and collapsing at the mid foot to get the additional range of motion required. If this range of motion of the talus is not available, then tendo achilles lengthening is indicated or gastrocnemius lengthening, in the manner of Baker "tongue-in groove" method which is less disabling and weakening than traditional tendo achilles lengthening.

As the valgus deformity establishes itself, the talus also moves downward and medial causing the mid foot to abduct making the valgus worse. The talus moves together with the tibia and fibula as a unit. Thus, as the tibia and fibula move internal, this will drive the talus internal (medial) also and pronate the foot (6, 7). The opposite is also true in the varus foot (clubfoot or cavovarus foot). Cavovarus has an opposite scenario of flatfoot (5). The talus is dorsiflexed in the ankle mortise. The leg is externally rotated and it carries the talus with it external causing cavovarus deformity. As the talus moves lateral and dorsiflexes, the hindfoot inverts and the mid foot must move medial and adduct (opposite than the valgus foot). The ist metatarsal must now be pulled to the supporting surface by the peroneus longus which has an improved vector of force due to the tarsal relationship. Thus, tendo achilles lengthening is not indicated in the cavorarus foot. As one looks at the lateral x-ray, you can see the calcaneus is not in equinus-it is in calcaneus position. The cavovarus foot is a superlocked and very stable foot internally under tremendous compression between the tarsal joint segments due to the tension bending effect of the plantar fascia which maintains the foot in inverted at the hindfoot and draws the forefoot against the hindfoot accentuating the arch architecture (8, 9). The laterally positioned talus and inverted hindfoot caused by the varus lead to lateral ankle instability. It is important that the surgeon not perform ankle stabilization operations on these feet. The problem is mechanical and when the

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cavovarus deformitiy is corrected, the hindfoot varus will be resolved and the lateral ankle instability will no longer be present. Multiple osteotomies, fusions and tendon transfers are often indicated in the cavovarus foot, especially when caused by neuromuscular diseases which is the most common cause of the cavovarus foot deformity (10, 11).

Equinovalgus

Equinovalgus is a complex deformity that involves tarsal joint collapse with talar declination at the ankle and sub talar joint level. It is a type of "reverse clubfoot" deformity. It can be classified as flexible, semi flexible or rigid. The "flexible forms" can be the so called hypermobile flatfoot with a short tendo-Achilles. These are not operated unless deformity is severe and causing some pain in the child or adult. Paralytic varieties exist in the flexible category and often these require an arthrodesis to compensate for paralysis of certain muscles, most commonly the posterior tibial muscle (12). Spontaneous rupture of the posterior tibial tendon from degeneration can also lead to progressive equinovoalgus due to loss the decceleration of lateral rotation of the leg produced by this muscle in stance phase of gait. Paresis (weakness or partial loss) of the anterior tibial muscle can also lead to progressive equinus, which eventually will compensate with dropfoot and then later, tarsal collapse and valgus foot posture. These conditions often require tendon transfers and/or arthrodesis to compensate for muscle loss or weakness (12, 13, 14).

Operations

Established equinovalgus will require either tendo Achilles lengthening or "tongue-in-groove" gastrocnemius lenthening to allow the necessary 10 degrees of dorsiflexion the biomechanics require. If paralysis of one of the tibial muscles is present, then a major arthrodesis is necessary, either sub talar or talo navicular (14). When tarsal joint degeneration or arthritis has developed in the old patient, then triple arthrodesis is preferred, in conjunction with a gastrocnemius lengthening to allow the talus to be repositioned during operation; otherwise, the surgeon will be forced to fuse the hindfoot in valgus since the talus will not be able to be lifted up at the talo navicular joint for realigment (15). If the deformity is not the result of a paralysis, then osteotomies of the os calcis are useful (16, 17, 18, 19). We use an open wedge osteotomy laterally (reverse Dwyer type) with a freeze dried bone allogeneic graft thus creating more varus in the hindfoot. One can also perform open dorsal wedge osteotomy of the medial cuneiform (also with freeze dried bone implant) to depress the 1st metatarsal and medial column of the foot for more stability. Translocation of the tibialis anterior into the navicular (Young's suspension), leaving its distal insertion intact, can also creat a medial column tension band and stabilization by making a new neoligament along the undersurface of the medial foot stabilizing it nicelly. Severe amounts of deformity will still require major triple arthrodesis, especially if degenerative joint disease is present in the sub talar and mid tarsal joints.

Cavovarus

Talipes cavovarus has an opposite biomechanical relationship to equinovalgus. The hindfoot is dorsiflexed on the mid tarsal joint and in varus. The forefoot is rotated downward along its medial aspect to purchase the floor in gait. The deformity is most often caused by neuromuscular disease, and therefore major tendon transfers are usually required, at an early age. The peroneus longus often is too active pulling the medial forefoot downward forcing the hindfoot into varus. Also, the posterior tibial muscle can excessively invert the hindfoot, forcing the peroneus longus to pull the medial forefoot downward (20). So, both of these important muscles play a role in this deformity and operation on one or both is often necessary when there is a neuromuscular basis to the deformity. Transfer of the posterior tibial muscle/tendon to the dorsum of the mid foot is the most common major tendon operation done in thees foot. It is brought through the interosseous membrane to the mid line of the foot. The hindfoot is corrected by a lateral wedge resection from the os calcis (Dwyer osteotomy) to bring it into slight valgus (21). The first metatarsal is elevated by basal dorsal wedge osteotomy. Steindler plantar release of the plantar fascia and first layer of intrinsic muscles (at the base of the heel) is an important procedure that releases the tension band effect and allows body weight to help reduce the deformity further following these other operations. Often hammer toes are present and painful in these patients. These forefoot deformities can also cause plantar flexion of the metatarsals making the forefoot painful. Repair of the hammer toes and release of the metatarsal-phalangeal joint contractures may improve the forefoot relationship to weight bearing.

In summary, remember that the mechanics of cavovarus and equinovalgus are opposite. Opposite surgical principals are often necessary as a result. Both deformities can occasionally require major triple arthrodesis as a salvage if the deformity is severe or mid tarsal joints. Thus, triple arthrodesis of the foot remains the major salvage operation for either of these deformities. Care must be taken to properly resect the necessary wedges of bone and joint to correct all deformity.

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