Subtalar realignment arthrodesis in the mid-stage neurogenic cavovarus foot

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Charcot Marie Tooth (CMT) disease is a progressive neuromuscular disorder that is often the underlying condition involved in the development of a symptomatic cavovarus foot. End-stage foot deformities frequently result in triple arthrodesis procedures performed later in the disease process. The main surgical goal is to achieve a stable, plantigrade foot. Ideally, treatment would avoid triple arthrodesis as this procedure increases adjacent joint demands and expedites development of resultant arthrosis. Some authors have stated that earlier intervention by tendon balancing techniques may alleviate the need for joint fusions in the future. Therefore, the timing of surgical intervention is paramount in the medical decision making process. Our case series reviews mid-stage cavovarus progression in patients with pedal instability and gait disturbances. Realignment subtalar arthrodesis is utilized to improve Kite's angle, reduce heel varus and re-establish subtalar joint (STJ) stability. Tendon balancing procedures should be performed in conjunction with STJ arthrodesis in order to achieve long standing correction and hopefully prevent the future need for conversion to triple arthrodesis.

Keywords: Charcot Marie Tooth, neurogenic, cavovarus, subtalar arthrodesis

One of the more common etiologies of cavus foot is an underlying neuromuscular disorder. Brewerton found that 66% of his cavus patients had a neuromuscular pathology, and of those, greater than 50% had Charcot-Marie-Tooth disease (CMT) [1].

In 1968 work by Dyck and Lambert classified this disease process as a hereditary sensory motor neuropathy [2,3]. Presently there are several subtypes described, with CMT type 1 being the most common form [4] CMT is a progressive disease that usually involves an imbalance of the antagonistic muscles inserting into the foot after loss of intrinsic musculature, resulting in a complex cavovarus deformity. The peroneus longus overpowers the tibialis anterior. In a similar fashion, the tibialis posterior vanquishes the peroneus brevis. This muscular asymmetry leads to an inverted rearfoot with plantar deviated first ray.

Due to these progressive imbalances, the timing of surgical intervention is paramount in the decision making process. Our surgical examples include mid to long-standing cavus deformity with variable signs of arthrosis and/or instability.

Case Examples

Case number one is a 37-year-old male (MH) with CMT who presented with significant weakness and gait instability. He was not able to wear an ankle foot orthoses (AFO) due to the amount of deformity and subsequent abrasions. Clinical evaluation revealed bilateral severe hammertoe deformities, plantarly deviated first rays and varus heel positions (Figure 1).
To address the right foot deformity, the following procedures were performed: Jones tenosuspension with hallux interphalangeal joint fusion, dorsiflexory 1st tarsometatarsal joint arthrodesis, hammertoe repair by fusion of the proximal interphalangeal joint (PIP), tibialis posterior tendon transfer, subtalar joint realignment arthrodesis and tendo-Achilles lengthening (TAL) (Figure 2). Note the improvement in Kite’s angle on the AP and lateral radiographs of the right foot versus the left. Additionally, note the significantly improved calcaneal alignment in the postoperative long-leg axial views.

Case number 2 is patient (TC) who was a 53-year-old male with CMT presenting with bilateral cavovarus foot deformities secondary to CMT (Figure 3). He complained of recurrent instability of the left ankle. Dynamic evaluation with fluoroscopy demonstrated significant subtalar joint instability (Figure 4).

Therefore, subtalar realignment arthrodesis was performed along with: 1st tarsal metatarsal joint (TMTJ) dorsiflexory arthrodesis; tibialis posterior tendon transfer, plantar fascial release and tendo-Achilles lengthening bilaterally (Figure 5).

Case number 3 is patient (RS) who was a 29-year-old male who also developed bilateral cavovarus foot deformities secondary to CMT (Figure 6). In order to correct the left foot we performed a tibialis posterior tendon transfer, Dwyer calcaneal osteotomy, peroneus longus to brevis tendon transfer, plantar fasciotomy and gastrocnemius recession (Figure 7). Note in the AP projection postoperative the poor alignment of the talar calcaneal joint (Kite’s angle). Additionally, in the axial views, note the lack of calcaneal alignment to the distal tibial axis.
**Figure 3** Patient TC, Preoperative axial views.

**Figure 4** Patient TC, preoperative stress of the ankle and subtalar joint. Note congruent ankle joint and lateral gap at the subtalar joint.

**Figure 5** Patient TC, postoperative axial views.

**Figure 6** Patient RS, preoperative views.
Case Series Summary

All three patients related good functional outcomes and increased stability after a minimum 5-year follow-up. However, the patients who underwent subtalar realignment had the best long-term alignment of the rearfoot complex. Furthermore, they were able to return to regular shoe wear with minimal use of their AFO bracing. The patient in case 2 (TC) had the most improvement with his left side subtalar instability treated by realignment arthrodesis of the subtalar joint. Conversely, patient in case 3 (RS) had the poorest result with his joint preserving osteotomies not employing the STJ realignment.

The joint sparing approach was chosen in case 3 because of his younger age. Improvements could have been made in the osteotomy incorporating more lateral translation in addition to the Dwyer procedure. Also note that with the calcaneal osteotomy there was little change in the AP Kite's angle.

Discussion

Thorough evaluation of the neurogenic cavus foot type is imperative to elucidate the best surgical options for the patient in establishing a plantigrade foot [5]. Radiographic assessment is also imperative with the long-leg axial view providing critical information [6–9]. Neuromuscular assessment allows physicians to determine which muscle groups are deforming vectors and which groups are paretic. Quite often in CMT, the primary deforming force is the dominating strength of the TP and PL over their weak antagonists. Subsequently, this results in a complex, progressive cavovarus foot type [10,11]. All of these factors substantiate that timing of intervention is a critical factor in the decision making process. Historically, triple arthrodesis for this condition has been advocated by many authors for best long term results [12–17]. However, more recent literature favors joint preserving osteotomies, especially in younger patients [9,18–22].

Some authors even advocate earlier surgical intervention by tendon rebalancing with the hopes of avoiding any form of surgical arthrodesis later in life [9,21,23]. Mosca proposed an individualized staged approach, with early intervention involving tendon transfers and osteotomies and end stage treatment incorporating triple arthrodesis [24]. Mosca reiterates that timing of the surgical procedures is very important in the decision making process. Our cases involved patients who displayed mid to late stage cavovarus deformities without evidence of secondary arthritic involvement.

The consideration of the subtalar joint (STJ) realignment arthrodesis is multifactorial. While all joints are involved in the rearfoot complex in CMT; we advocate that arthrodesis of the subtalar joint offers an ideal apex from which to address the triplanar deformity while preserving some midtarsal joint motion [25,26]. In order to appropriately correct a deformity, the authors support Paley’s theory of a three dimensional approach that allows for correction at the center of rotational angulation (CORA) [27]. In this case, we are addressing the mechanical axis of the subtalar joint.
Figure 8 3D CT of cavus foot. Reveals curved medial border of heel suggesting Dwyer type procedure (Left). CT of same foot and patient that was rotated eliminating the “perceived” curved border (Right). This illustrates that the varus heel is positional versus structural.

Most studies evaluate this condition in two dimensions therefore a common recommendation to address heel varus (in 2D) is a calcaneal osteotomy (Dwyer) with or without lateral displacement [28,29]. Even the Coleman-Chesnut block test only evaluates the heel in the coronal plane [30].

Figure 9 In cavus/clubfoot, the anterior process of the calcaneus is under the talar head yielding a varus and slight equinus deformity of the calcaneus. Lateral displacement of the anterior process will correct the heel varus. Reprinted from Ponseti and Smoley JBJS 1963.

While we acknowledge that a wedge calcaneal osteotomy helps align the heel to the tibia in the coronal plane; it does not provide improvement of Kite’s angle or address instability of the STJ [31]. A recent 3D study by Pfeffer et al., acknowledged the lack of correction in all three planes with a Dwyer, oblique osteotomy, and the more technical Z-osteotomy [32]. The calcaneus does not solely move in the frontal plane by inverting the posterior tuber. It is a triplane deformity with its axis through the subtalar joint that can be best appreciated on CT studies [33] (Figure 8). The varus heel position commonly seen in CMT patients is notably similar to the calcaneal position in patients with clubfoot deformity. With this in mind, when we apply the biomechanical principles as advocated by Ponseti, the deformity will reduce during surgical repair [34–36]. His evaluation of the mechanics of the subtalar joint was inspired by the findings of Huson [37] and Farabeuf [38]. During subtalar realignment, the beak of the calcaneus is abducted, dorsiflexed and rotated about the subtalar axis producing a valgus positioning of the calcaneal tuber along with improvement of Kite’s angle (Figure 9).
Summary

When addressing rearfoot malalignments, especially in patients with CMT, it is important to understand the complex biomechanical axes of the rearfoot. The calcaneus moves in a triplanar fashion about the subtalar joint axis. A cavovarus deformity develops from the underlying neuromuscular imbalances. After addressing these imbalances usually with tendon transfers; care should be taken to evaluate for any arthroisis, instability and malposition of the calcaneus. We have found that realignment arthrodesis of the subtalar joint offers improved talocalcaneal alignment, calcaneal re-positioning and stability in the mid to late stage CMT patient.

References

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