Evaluation and Surgical Management of the Overcorrected Clubfoot Deformity in the Adult Patient

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KEYWORDS
- Clubfoot • Overcorrection • Dorsal bunion • Flattop talus
- Dorsal navicular subluxation

KEY POINTS
- The overcorrected clubfoot is a complication seen as the result of attempts to surgical address previously existing clubfoot deformity.
- Despite the infrequency with which the posteromedial release is performed today, this entity will present occasionally to the orthopedic foot and ankle surgeon.
- A sound understanding of the underlying muscle imbalance is essential when addressing the resulting deformities.
- The surgical aim is to provide the patient with a pain-free, stable, and plantigrade foot that is in neutral alignment.

INTRODUCTION

The overcorrected clubfoot represents a spectrum of deformity that follows a fairly consistent pattern. It may remain asymptomatic for years and the patient often presents only in adulthood. Historically, surgical correction obtained by extensive soft tissue release was the standard of care; the posteromedial release being the mainstay of treatment. Long-term outcomes of clubfoot patients treated with a posteromedial release have demonstrated significant stiffness and arthritis of the foot with revision surgery to address undercorrection or overcorrection a frequent finding.1

In comparison, modern treatment of clubfoot is by Ponseti casting, which has been shown to have good long term outcomes.2-5 Most patients are successfully treated nonoperatively with Ponseti casting6 and only in a minority of these patients, surgical

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intervention may be used to augment correction or address recurrent deformity. How-
however, the more traditional posteromedial release is still performed for primary correc-
tion in some centers and more commonly for the management of the resistant or
recurrent clubfoot. The outcome of treatment, whether nonoperative or operative,
seems to be related in some degree to the etiology, and this should be taken into
consideration when managing nonidiopathic clubfoot.\textsuperscript{7,8}

**PRESENTATION**

**History**

Overcorrection occurs almost exclusively in patients who have had prior surgery, usu-
ally in the form of a posteromedial release, completed at around 2 years of age. It is not
uncommon for many patients to have had additional surgery to either correct a resid-
ual deformity or to address overcorrection. There is another spectrum of problems that
we treat, where patients have been quite stable for decades but where an anterior
ankle cheilectomy is performed for impingement. Decompression of the anterior tibia
exposes the underlying abnormal ankle motion secondary to a structurally abnormal
flat top talus and, instead of providing pain relief, the cheilectomy leads to an exacer-
bation of the underlying ankle arthritis.

Patients with an overcorrected clubfoot often present much later in life. They typi-
cally give a history of managing for several years with few symptoms, despite the pres-
ence of deformity. The onset of acute symptoms or the deterioration of preexisting
symptomatology is typically related to minor trauma, such as a sprain of the foot. Dur-
ing early adulthood, the complaints center mostly around the often marked deformity
and stiffness that limits activity. These factors lead to discomfort and difficulties with
shoe wear. Degenerative joint disease is often seen later in adulthood and is associ-
ated with a prior history of good function followed by the insidious onset of progressive
pain.

**Examination**

Physical examination should begin with observation of the gait cycle, the posture of
the foot during stance, and while performing a heel rise, if possible. Careful assess-
ment of hindfoot alignment is necessary and its relation with the fore foot should be
established.

The authors commonly observe weakness when performing a heel rise indicating a
weak or nonfunctioning posterior tibial tendon. When performing a heel rise, the
hindfoot does not swing into varus, but may correct only to the midline or stay in fixed
valgus, indicating a rigid deformity. To assess for forefoot supination, the ankle is held
in a neutral position and the hindfoot alignment corrected while observing the posture
of the forefoot. Fixed supination of the forefoot is often seen in the setting of pes pla-
nus, and this finding is worse with more flexibility of the hindfoot. With significant hind-
foot valgus, tenderness at the tip of the fibula or over the peroneal tendons is the result
of calcaneofibular impingement. The navicular is frequently prominent dorsomedially
and subluxated from a normal position at the talonavicular and naviculocuneiform
joints where arthritis may be present. Tenderness over the anterior aspect of the ankle
joint especially in dorsiflexion is caused by anterior ankle impingement.

The ankle, subtalar, and Chopart’s joints should be evaluated for mobility and signs
of arthritis. It may be difficult to accurately identify the symptomatic joint when all the
joints of the hindfoot and ankle radiographically seem to be involved in the process.
Selective intraarticular injection using 1% lidocaine under fluoroscopic guidance
may help to differentiate between these potential sources of pain. Forefoot deformity
is often marked by an elevated first ray with a dorsal bunion of varying prominence. In these feet, hallux metatarsophalangeal (MP) joint dorsiflexion is absent owing to a contracture of the flexor hallucis brevis (FHB). As the first metatarsal moves into more dorsiflexion, the FHB contracts pulling the hallux into even more plantar flexion. This position of the hallux now pushes up on the first metatarsal, which in turn causes more elevation of the first ray until there is a fixed flexion contracture of the hallux with compensatory hyperextension of the hallux interphalangeal joint.

Examination of the strength of the muscles is a good way to understand the underlying dynamic imbalance that is taking place. This evaluation will allow the treating surgeon to better understand the cause of the deformity. Plantar flexion is almost always weak with little excursion of the Achilles tendon owing to the abnormal gastrocnemius/soleus muscle complex and scarring from prior lengthenings of the Achilles tendon. Peroneal muscle weakness seems to be part of the pathology leading to clubfoot, although the reason for this remains uncertain. Scarring of the peroneal tendons is often the result of subfibular impingement or a previous posterolateral release. The anterior tibial tendon remains normal and, therefore, relatively strong compared with its antagonist, the peroneus longus. The imbalance eventually causes an elevation of the medial column often with a varying degree of a dorsal bunion present. The evolution of this is discussed elsewhere in this article. Patients can present with isolated deformities but more often with multiple complaints or deformities.

**Nonoperative treatment**

Nonoperative treatment options need to be considered before embarking on surgery. These measures can help the patient to overcome a temporary exacerbation of their symptoms and it may enable some to cope without surgery. The use of a custom orthotic often proves to be the most useful and typically consists of a semirigid orthotic support with a medial heel wedge and a post under the first metatarsal to support the elevatus. This support counters the hindfoot valgus and provides support for the resulting elevation in the medial arch. In cases where the symptoms results from painful motion in a degenerative ankle, pain can be controlled with custom bracing such as an Arizona brace or ankle foot orthosis.

**MANAGEMENT OF SPECIFIC DEFORMITIES**

**Hindfoot Valgus**

Several factors play a part in this deformity, which is among the most common features of overcorrection\(^\text{10}\) (Fig. 1).

![Fig. 1. (A, B) A 23-year-old patient with an overcorrected left club foot after surgery in childhood. The patient presented with a valgus deformity of the left hindfoot, a symptomatic dorsal bunion, and a painfully subluxated talonavicular joint.](image)
the interosseous talocalcaneal ligament can lead to subtalar instability with lateral translation of the calcaneus relative to the talus and valgus malalignment. Internal fixation by pinning of the subtalar and talonavicular joint after release decrease the risk of overcorrection.\textsuperscript{11,12} Intuitively, one tends to attribute the hindfoot valgus to overzealous release of the medial structures, the posterior tibial muscle and talocalcaneal interosseous ligament.\textsuperscript{13} However, another likely cause could be the insufficient release of the calcaneofibular ligament lateral, which was shown by Ponseti to be thickened and shortened in the recurrent clubfoot.\textsuperscript{14,15} This results in tethering of the foot at the posterolateral corner and, as the foot is dorsiflexed, the subtalar joint is pulled into valgus. With the hindfoot in valgus, the ankle does not function normally. Insertion of the Achilles tendon shifts to a position lateral to the axis of the ankle and subtalar joint and weakens its plantar flexion power. This converts the Achilles tendon into a deforming force that exerts a valgus moment onto the hindfoot that perpetuates the deformity.

The goal of reconstruction is to obtain realignment of the hindfoot by addressing the deformity as close as possible to its apex. It is therefore important to discern ankle valgus from subtalar joint valgus (Fig. 2). In the overcorrected clubfoot, ankle joint valgus often presents with associated calcaneofibular and anterior ankle impingement. In these cases, realignment should be performed with a supramalleolar closing wedge osteotomy.

If ankle joint alignment is normal, the algorithm focuses on the subtalar joint. When considering the subtalar joint the factors taken into consideration are (1) the severity of the deformity, (2) tenderness at the sinus tarsi, (3) the relative flexibility or rigidity of the subtalar joint, and (4) radiographic signs of joint degeneration. In less severe deformities without signs of joint pain, the authors prefer to perform a medial displacement osteotomy of the calcaneus (Fig. 3). If the deformity is severe or significant joint degeneration is present, the authors tend to perform an arthrodesis of the subtalar joint. Realignment can be difficult because the hindfoot may be in severe valgus. Correction of the valgus with an arthrodesis inevitably leads to a large lateral defect that is filled with generous amounts of bone graft. This situation, however, presents a difficulty with respect to decision making of placement of the incision for the arthrodesis. If there is significant valgus deformity, a laterally based incision will not close if the valgus is corrected, and less so if bone graft is used to elevate or change the position of the hindfoot. For this reason, the authors prefer to use a medial approach to correct the subtalar joint when marked hindfoot valgus is present. The same concept applies to correction of deformity when a triple arthrodesis is planned, when we will use a medial approach to the triple arthrodesis (see references for medial triple, Myerson, etc).

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{hindfootAlignmentRadiographs.png}
\caption{(A, B) Hindfoot alignment radiographs demonstrates the valgus deformity in the left hindfoot. A weight bearing anterior posterior radiograph of the ankle excludes a valgus deformity at the level of the left ankle joint.}
\end{figure}
A valgus deformity may be present at both levels and the hindfoot should be evaluated carefully for residual valgus after correction of ankle valgus. When present, consideration should be given for the need of a medializing calcaneal osteotomy. In addition to the subtalar joint, the status of the talonavicular joint should be assessed, which in our experience is more commonly involved in the deformity, necessitating a triple arthrodesis.

**Dorsal Bunion**

When dealing with the dorsal bunion, it is important to recognize the muscular imbalance created by the relatively normal, and therefore strong, anterior tibial tendon overpowering a weak peroneus longus. This results in an elevation of the first ray and supination of the forefoot (Fig. 4). The weak plantar flexion power of the abnormal gastrocnemius–soleus is compensated for by plantar flexion of the hallux MP joint using the secondary plantar flexors such as the FHB. Over time, a functional contracture of the FHB develops. During ambulation, the plantarflexed hallux and proximal

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**Fig. 3.** Intraoperative view of the medializing calcaneal osteotomy performed via a lateral approach to address the hindfoot valgus.

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**Fig. 4.** Bilateral symptomatic dorsal bunions. Note the elevated first metatarsal and contracted flexor hallucis brevis.
phalanx exert a dorsally directed force at the MP joint when the toe strikes the ground, forcing the first ray into more elevation, resulting in a vicious cycle of worsening deformity\textsuperscript{16} (Fig. 5). With cast treatment, care is taken to supinate the forefoot because pronation increases the underlying cavus deformity. Despite the correct treatment, some patients treated in a cast may have continued supination of the forefoot as well as a dorsal bunion. This muscular imbalance is therefore also seen in feet treated with the Ponseti method at times, necessitating a transfer of the anterior tibial tendon lateral to balance its supination force.\textsuperscript{17}

Correction of a dorsal bunion in the setting of an overcorrected clubfoot fails if the underlying muscular imbalance is not corrected and we, therefore, start with a transfer of the anterior tibial tendon. The entire anterior tibial tendon is released at the beginning of the procedure and transferred only once the other corrections are completed (Fig. 6). This sequence gives a much better appreciation and feel for the balance of the foot, which will dictate how far laterally in the midfoot the transfer needs to be done. For an isolated dorsal bunion, a transfer to the middle cuneiform is usually sufficient to restore balance. By removing the anterior tibial tendon as a deforming force while maintaining adequate dorsiflexion power, the muscle imbalance is corrected.

The question then becomes whether to fuse the first metatarsocuneiform joint or to perform an osteotomy of the metatarsal. It is the senior author’s experience that the rigidity of the deformity is usually of such severity that full correction is impossible with an osteotomy. The authors therefore perform a fusion of the metatarsocuneiform joint in plantar flexion by removing a plantar-based wedge at the metatarsocuneiform joint. This technique allows for some shortening of the metatarsal with relaxation of the FHB and improved dorsiflexion of the first MP joint. Closing the plantar-based wedge usually requires the forceful dorsiflexion of the hallux MP joint to generate enough pressure. Although the force on the hallux is maintained, the saw blade is introduced repeatedly into the metatarsocuneiform joint along the plantar surface to gradually decompress and plantar flex the arthrodesis. The authors do not recommend a dorsal opening wedge osteotomy of the first metatarsal, because this is usually not powerful enough and the further lengthening of the metatarsal causes even more stiffness of the MP joint owing to tensioning the FHB.

Once the elevated first ray has been addressed with a correction of its sagittal alignment, the posture and range of motion of the hallux at the first MP joint is evaluated with the ankle in a plantigrade position. If the first MP joint dorsiflexion is

Fig. 5. (A, B) Preoperative photo and radiograph of a patient with a symptomatic dorsal bunion. Elevation of the first metatarsal is caused by over pull by the anterior tibial tendon resulting in a contracture of the flexor hallucis brevis. For this patient, motion of the hallux metatarsophalangeal joint was important and therefore a reconstruction was performed without fusion of the metatarsophalangeal joint.
adequate without undue tension of the FHB, transfer of the anterior tibial tendon is performed. When the tension in the FHB is such that dorsiflexion is limited, further shortening or plantar flexion is desired. The authors typically perform a shortening oblique osteotomy of the first metatarsal head. This procedure is an oblique extra-articular osteotomy of the first metatarsal that moves the metatarsal head plantarward and proximally. The additional shortening allows for further relaxation of the FHB. If further dorsiflexion is needed, a Moberg osteotomy of the proximal phalanx of the hallux improves the sagittal position of the toe without actually changing the MP joint arc of motion (Fig. 7). In cases where there is significant hallux MP joint stiffness, a fusion of the joint gives reliable correction of the deformity. Even with a fusion of the hallux MP joint, it is still necessary to transfer the anterior tibial tendon and address the elevated first metatarsal to achieve adequate alignment and avoid recurrent deformity (Fig. 8).

Fig. 6. Reconstruction of the dorsal bunion commences with release of the main deforming force, the anterior tibial tendon. It is transferred laterally once the realignment of the first ray has been completed. The symptomatic dorsal subluxation of the talonavicular joint was addressed with fusion of the talonavicular and medial naviculocuneiform joints with restoration of Meary’s angle.

Fig. 7. (A, B) Postoperative photo and radiograph of the same patient as in Fig. 6. The postoperative lateral radiograph shows the functional position and arc of motion that was restored to the hallux by plantar flexion and shortening osteotomies of the first metatarsal augmented with a Moberg osteotomy of the hallux proximal phalanx. Valgus of the hindfoot was addressed with a medializing calcaneal osteotomy and the arthritic and subluxated talonavicular joint was fused.
Dorsal Subluxation of the Navicular

Subluxation of the navicular is seen exclusively in postoperative clubfeet. It results from an attempt to correct the plantar medial orientation of the navicular on the talar head, which characterizes the cavus deformity seen in clubfeet. The navicular is thicker medially than laterally and, with release of the medial talonavicular ligaments and capsule only, an attempted reduction in a dorsal direction results in rotation around the lateral unreleased talonavicular ligaments. This release causes a rotational deformity of the navicular to a dorsal and medial position on the talar head. Elevation

Fig. 8. (A–D): Preoperative and postoperative radiographs of a 41-year-old patient with a symptomatic dorsal bunion after prior correction of the clubfoot with a triple arthrodesis. She also complained of chronic pain under the plantar aspect of her heel. Note the elevated first ray and small but very prominent plantar aspect of the posterior tuberosity (A, B). Correction was obtained by transfer of the anterior tibial tendon, and plantar flexion of the first ray by removing a plantar wedge and fusion of the medial naviculocuneiform joint. The hindfoot valgus was addressed with a medializing calcaneal osteotomy with an additional closing wedge to reduce the heel prominence (C). The dorsal bunion was treated with fusion of the metatarsophalangeal joint (D).
of the thicker medial side of the navicular gives it a wedge-shaped appearance on a lateral radiograph.\textsuperscript{18}

This deformity is seen most commonly in the setting of a residual clubfoot with persistent cavus and hindfoot varus. However, in the case of overcorrection, it is associated with hindfoot valgus and arthritic change in the talonavicular joint. A variable amount of subluxation can be found; in severe cases, there is marked plantar flexion of the talar head akin to a congenital vertical talus. On examination, a palpable prominence is present where the navicular is subluxated dorsally. Tenderness of the joint is indicative of degeneration, a common finding that is confirmed on radiographs.

The treatment algorithm here accounts for the severity of the patient’s deformity and the presence of symptoms or signs of subtalar arthritis as found with clinical examinations and radiographs. In the absence of subtalar arthritis and with passively correctable valgus, a talonavicular arthrodesis is performed with a medializing calcaneus osteotomy. In more severe and especially rigid deformities with subtalar involvement or signs of subfibular impingement, the authors include the talonavicular joint as part of a triple arthrodesis.

The outcomes of previous attempts at open reduction of the talonavicular joint were not encouraging and are therefore not recommended.\textsuperscript{19,20} Multiple authors have found favorable outcomes when a talonavicular arthrodesis is performed for dorsomedial subluxation with persistent deformity after clubfoot surgery.\textsuperscript{21,22} Mubarak and colleagues reported on 13 patients (age range, 6–17 years) in whom a talonavicular fusion was performed for symptomatic talonavicular subluxation.\textsuperscript{22} All patients had been treated with previous complete posteromedial release. The average follow-up was 3 years with 12 of the 13 patient’s symptom free at final follow-up. After surgery, they found a correction of talonavicular subluxation from 42% to 6% using measurement from a lateral weight-bearing radiograph. In addition, they found a restoration of the talo–first metatarsal angle and the calcaneal pitch. They concluded that talonavicular arthrodesis realigns the medial column allowing for normal weight distribution under the forefoot, but that long-term follow-up is needed to assess the effect on the naviculocuneiform joints. An arthrodesis of the talonavicular joint will not correct the elevation of the first metatarsal, which still requires a lateral transfer of the anterior tibial tendon and other maneuvers to correct the elevates, as described.

**Flat Top Talus**

Flattening of the talar dome is one of the hallmarks of deformity seen in clubfeet (Fig. 9). The exact cause has not been defined. Intuitively, one expects that it is caused by the
pressure exerted across the tibiotalar joint with forced dorsiflexion during cast treatment, but little evidence exists to support this. A duration of manipulation and casting of longer than 3 months may be contributory.\textsuperscript{23,24} An association with peritalar surgical release has also been found, but the exact mechanism is as yet undetermined.\textsuperscript{25}

Flattening of the talus is seen as a spectrum of involvement ranging from minimal loss of sphericity to almost complete flattening of the talar dome. Some degree of talar flattening was found in up to 74\% of clubfeet, but gross flattening was reported to be present in only 1.5\% of cases in 1 series. The degree of flattening seems to strongly influence ankle motion, which in turn is among the major factors influencing functional outcome.\textsuperscript{26} The abnormal spherical shape of the talar dome results in abnormal hinge like motion instead of the normal rolling and gliding ankle joint motion (Fig. 10). It seems that this deformity is already present at birth and, despite some improvements that may be obtained with Achilles tendon lengthening and soft tissue release, the ultimate outcome of ankle motion may be predetermined by the degree of talar dysplasia present.\textsuperscript{27,28} Anterior ankle impingement with prominent osteophytes is a common finding. It has been our experience, however, that anterior cheilectomy does little to improve this deformity, because the osteophytes are indicative of the underlying arthritis and abnormal motion. A cheilectomy does not address this situation, and therefore the symptoms and motion do not improve significantly after cheilectomy; indeed, in these authors’ experience, the slight increase in motion increases crepitus and pain and this procedure is rarely indicated.

Treatment of end-stage ankle arthritis in the setting of a clubfoot is challenging. Maintaining motion in the ankle would be ideal and theoretically this could protect more distal joints from added mechanical load and further degeneration. However, when conservative measures fail to address symptomatic ankle arthritis, these authors have found that arthrodesis of the ankle or an ankle replacement to be a very realistic and reliable treatment option, knowing that the patient is at risk of adjacent joint arthritis.

In an attempt to decrease anterior impingement and improve ankle range of motion, Knupp and colleagues\textsuperscript{29} performed a supramalleolar tibial osteotomy in 14 adult patients. All had calcaneofibular impingement with hindfoot valgus with additional anterior ankle impingement present in 5 of them. In the cases where combined lateral calcaneofibular and anterior impingement was present a biplanar osteotomy was performed as an anterolateral closing wedge osteotomy. The mean total ankle range of motion for all patients in the study showed a statistically significant improvement.

Fig. 10. Lateral radiograph illustrating the abnormal hinge like motion of the ankle joint seen commonly in association with a flat top talus.
from a mean of 25° to 29°. The authors do not agree with the reported outcome of the true range of motion of the ankle in this group of patients. Strictly speaking, it is not possible to obtain any increase in the range of motion because the concept of improving motion by performing an osteotomy is that seen in a Moberg osteotomy of the hallux proximal phalanx. Rather than improving the total arc of motion, it serves to bring the existing range of motion into a different plane. Although this may be useful to obtain a plantigrade foot in the presence of an equinus deformity of the ankle, it cannot improve actual motion in an abnormal joint.

A total ankle replacement in the setting of a clubfoot is an interesting concept, but there are several salient points that complicate this procedure. To begin with, the abnormal hinged ankle motion that gave rise to the joint degeneration is likely to persist owing to the abnormal posterior soft tissue envelope. This includes the Achilles tendon, posterior tibial tendon, and posterior capsule that may be severely scarred secondary to multiple surgeries and will limit the potential range of motion that could be obtained. In addition to that, several anatomic factors need to be taken into account such as the small and narrow talus, the posterior position of the fibula, and thus the small surface area for the prosthesis. Nonetheless, this treatment remains a viable alternative for managing these deformities, particularly when some ankle range of motion is desirable. Keep in mind, however, that this procedure can only be performed in the presence of a plantigrade foot, so that the replacement should be staged after correction of the forefoot and hindfoot deformity.

SUMMARY

The overcorrected clubfoot is a complication seen after surgical release of the foot. Despite the infrequency with which the posteromedial release is performed today, this entity presents occasionally to the orthopedic foot and ankle surgeon. A sound understanding of the underlying muscle imbalance is essential when addressing the resulting deformities. The surgical aim is to provide the patient with a pain-free, stable, and plantigrade foot that is in neutral alignment. Preserving joint motion is preferable, but not always possible. Several distinct deformities are seen commonly and our treatment algorithm for these was discussed. The underlying pathoanatomy, which includes the skeletal and soft tissue structures, complicates treatment and necessitates a different approach. As the body of literature dealing with the overcorrected clubfoot continues to expand, it will aid the treating surgeon to achieve an optimal outcome with great benefit to the patient.

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