

Reconstructive Options for Failed Flatfoot Surgery

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Failed outcomes after flatfoot reconstruction result from residual pain in degenerative joints or the failure to achieve a rectus plantar grade foot. Despite ongoing controversies regarding treatment of the degenerative flatfoot, there is no single accepted paradigm or treatment algorithm [1]. Further complicating the treatment dilemma are shortcomings in characterization of the degenerative flatfoot deformity. For the purpose of this article, the progression of the degenerative flatfoot characterized by the posterolateral subluxation of the calcaneus beneath the talus and dorsolateral rotation of the forefoot around the talar head is referred to as dorsolateral peritalar subluxation [2]. Current classification systems lack accurate detail in the failing structural components of flatfoot deformity that contribute to the deterioration of the foot [3–5]. They do not describe the failure of the static supporting structures in the foot that is secondary to the dynamic muscular imbalance created by a ruptured or dysfunctional posterior tibial tendon. Moreover, the role of equinus and the significant deforming force it has on the antagonist structures in the foot and ankle are also not universally appreciated [1]. The consequences of the complex decision-making process and the lack of absolute criteria in treatment can occasionally result in less than optimal outcomes. Clearly, it is difficult to develop a surgical strategy for every flatfoot condition that ensures optimal correction and meets patient satisfaction and functional goals. Making decisions even more calculating is the ability or inability of any given procedure or combination of procedures to achieve optimal correction. Dogmatic decision making often guided by incomplete characterization of the condition and the surgeon's reliance on familiarity with only a few techniques can result in less than favorable results. The following discussion attempts to address several issues

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regarding failed flatfoot reconstruction and reviews options that can be exercised to achieve successful revision.

Characterization of deformity

An evaluation of the flatfoot is the first critical step in reaching an optimal surgical plan. This evaluation must encompass the dynamic muscle imbalance that may exist with posterior tibial dysfunction and contracture of the superficial posterior compartment of the leg. Subtle subluxation of the medial column, such as naviculocuneiform fault or subluxation, or tarsometatarsal instability will contribute to medial column instability and loss of arch height (Fig. 1). Adaptive forefoot changes such as supinatus, if rigid and not surgically addressed, will lead to lateral column overload when the hindfoot valgus is properly corrected. Failure to recognize all aspects of the deformity may result in less than optimal correction and leave the patient with the same preexisting biomechanical faults, which may deteriorate over time.

Soft tissue

An often overlooked aspect of evaluation in the adult flatfoot are the secondary adaptive changes that develop as a consequence of lateral peritalar



Fig. 1. Lateral weight-bearing radiograph of foot with lateral peritalar subluxation and naviculocuneiform fault. Medial column instability if not addressed will be a future source of degenerative collapse.

subluxation, such as forefoot supinatus, lateral hindfoot soft tissue contracture, progressive joint stiffness, and adaptive subluxation of the medial column and subtalar joint. A thorough understanding of the structures that have failed and of those that are failing or at risk of failing should assist the foot and ankle surgeon in selecting the most comprehensive surgical plan. More important, underlying muscular imbalance and biomechanical faults inherent to each foot must also be addressed at the time of surgery. Equinus has a significant role in degenerative lateral peritalar subluxation, and every attempt should be made to identify and treat this component of the deformity.

Soft tissue reconstructive procedures such as repair of a ruptured posterior tibial tendon or flexor digitorum longus transfer often fail to adequately correct the deformity and afford a durable plantar grade foot. Furthermore, the underlying osseous malalignment or joint instability is ignored. It is critical not to overlook useful adjunctive reconstructive procedures, in addition to osseous procedures, to restore muscle balance in the foot.

Malunion

Residual deformity is a common reason for failed flatfoot surgery. Undercorrection of hindfoot valgus can be the most troubling of all failed flatfoot procedures and is the most common indication for revision surgery [6,7]. A subtalar fusion or triple arthrodesis with valgus malalignment will create eventual deltoid ligament failure and predictable degeneration of the ankle (Fig. 2) [8–10]. Studies further show that restoring medial stability with hindfoot realignment will significantly improve the degenerative forces on the deltoid complex and posterior tibial tendon [8–10].

Excessive lateral subtalar joint debridement, inadequate debridement of the anterior and middle facets, and improper positioning can all contribute to the valgus hindfoot malalignment. Although less common, varus malunion can also be created by overcorrection of the hindfoot. Excessive valgus or varus malalignment is generally poorly tolerated, leading to medial ankle instability or lateral column overload. Small degrees of residual hindfoot valgus or varus malalignment can be fine tuned with a posterior calcaneal osteotomy (Fig. 3). Residual hindfoot valgus of more than 10 degrees usually requires a takedown revision arthrodesis. In addition to the hindfoot realignment osteotomy, care must be taken to assess the forefoot and ensure it remains plantar grade with the change in hindfoot alignment. Often, the midfoot requires an osteotomy when large degrees of hindfoot alignment are corrected.

Inadequate reduction of the midtarsal joint will leave the forefoot abducted and the forefoot predictably in varus. A medial closing wedge through the talonavicular fusion can restore the forefoot alignment. Often, the restoration of alignment must be made visually after arthrodesis

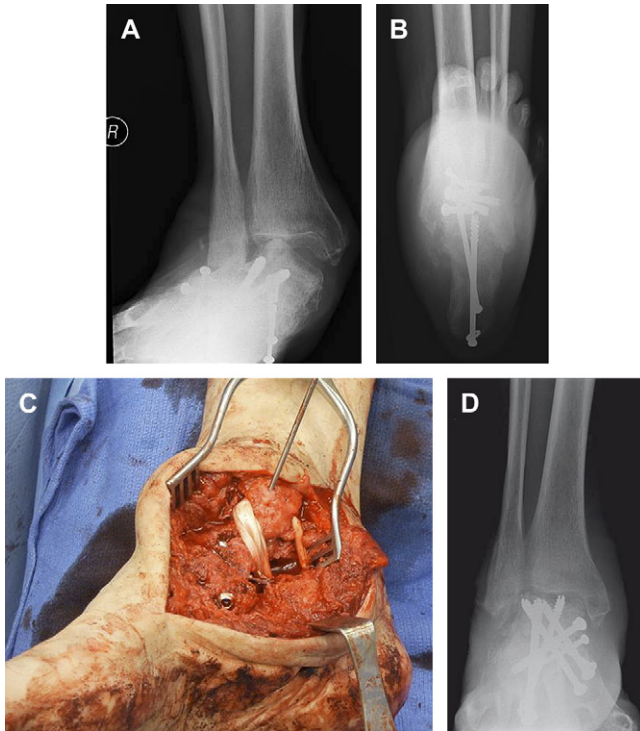


Fig. 2. Revision triple arthrodesis and deltoid reconstruction as an alternative to pantalar arthrodesis. (A) Valgus ankle collapse after malunited triple arthrodesis. (B) Restoration of the hindfoot alignment with revision subtalar fusion through a medial approach. (C) Allograft deltoid reconstruction to restore medial ankle stability. (D) Six-month postoperative film of well-aligned ankle with stable medial deltoid complex.

procedures because the usual articular landmarks are no longer appreciated. A good intraoperative endpoint for forefoot correction is to restore the second ray with the tibial axis (Fig. 4).

In addition, careful attention must be paid in cases of severe hindfoot valgus operated on through the standard lateral approach, because lateral subluxation of the subtalar joint many times is not entirely reducible. The foot and ankle surgeon must understand that there is an accompanied lateral translation of the calcaneus beneath the talus as well as a valgus angulation. Attention should be paid to the middle and anterior facets as well as medial soft tissue, which, if not fully debrided or released, may prevent anatomic reduction of the joint. With any procedure involving a subtalar arthrodesis, the long axis of the calcaneus must be restored under the mechanical axis of the tibia, ensuring a parallel relationship. Intraoperative hindfoot alignment views assist with this determination (Fig. 5). Even with the patient supine, a confident decision can be made with the combination of visual and radiographic assessment.



Fig. 3. Residual hindfoot valgus after triple arthrodesis realigned with a medializing calcaneal osteotomy. In addition, a midfoot derotational osteotomy must be performed to maintain a plantar grade forefoot.

Malunion with a valgus ankle secondary to deltoid insufficiency is a reconstructable deformity as long as the hindfoot and forefoot deformity are properly corrected. Deltoid reconstruction is a poorly documented technique in end-stage flatfoot reconstruction. Historically, a triple arthrodesis and bracing or a pantalar arthrodesis have been considered the treatments of choice. With the developing technology of total ankle joint replacement, deltoid ligament reconstruction preserves the option of joint replacement over a pantalar arthrodesis.

An alternative approach for subtalar arthrodesis is from the medial approach (Fig. 6). The author believes that a medial approach is superior to the lateral approach to adequately correct severe degrees of valgus deformity and avoid the lateral soft tissue adaptation that can make skin closure difficult. A more thorough debridement of the middle and anterior facets can be accomplished from the medial approach. Furthermore, the approach can be extended proximally for deltoid ligament or posterior tibial tendon repair if necessary.

Nonunion

Nonunion is an unfortunate complication of any skeletal procedure. Careful attention to thorough joint debridement, stable fixation, bone graft augmentation, and appropriate healing time does not always ensure



Fig. 4. Triple arthrodesis with midtarsal malunion. The forefoot is abducted and in varus with respect to the hindfoot. (A) A plantar medial closing wedge osteotomy can restore forefoot alignment. (B) Restoring the second ray alignment with the tibial axis is an important intraoperative assessment to ensure proper correction.

a successful union. In cases of nonunion, the foot and ankle surgeon should attempt to identify a reason for the nonunion and correct it with a revisional operation. If motion across the nonunion site has resulted in loss of optimal correction, a complete re-evaluation should be done with respect to the residual deformity. Often, the nonunion must be completely taken down and the residual deformity corrected to achieve favorable results. Usually, the reason for poor healing is discovered at the time of revision surgery. Commonly, a dense mantle of subchondral bone or articular cartilage is left behind which acts as a poor bone healing interface. Poorly placed or insufficient internal fixation is more common than hardware failure. Bone graft augmentation is generally recommended at the time of revision arthrodesis. Currently, several osteobiologic options are commercially available for bone grafting. For large defects, autogenous bone is generally recommended. In addition, locked plate fixation reduces the need for a structural bone graft to fill voids and maintain stability.

Lateral column complications

Failure of lateral column osteotomy is seen with undercorrection, malunion, or nonunion. Generally, undercorrection is found in instances where

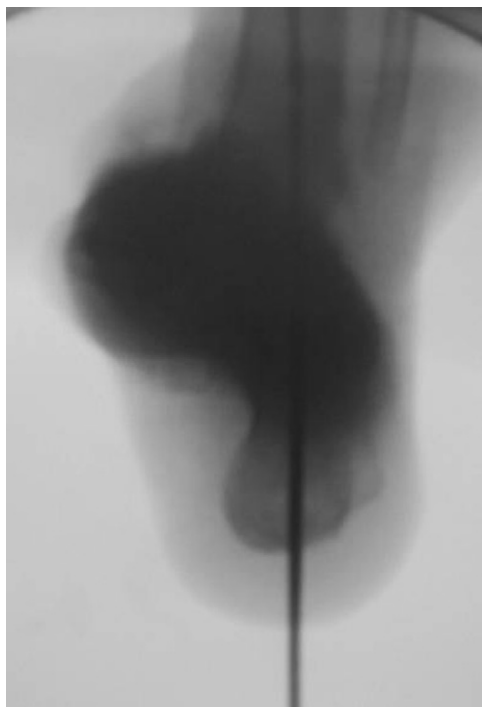


Fig. 5. Intraoperative hindfoot projection to assess the relationship of the calcaneus to the tibial axis. This view in addition to visual assessment ensures a confident decision regarding alignment.

the subtalar complex is not sufficiently flexible to allow for complete reduction. In these instances, the hindfoot is left in valgus. Intraoperative assessment should indicate the need for an additional osteotomy of the posterior calcaneus to restore the calcaneal tuber with the mechanical axis of the limb.

Malunion of the anterior calcaneal process occurs as a result of various factors. Failure to symmetrically distract the osteotomy, improper graft size or placement, and inadequate fixation all contribute to the deformity. Malunion with an Evans osteotomy generally results in dorsal subluxation with or without rotation of the anterior process of the calcaneus. The incongruity created in the calcaneocuboid joint can result in painful degenerative arthrosis [11]. Nonunion after calcaneocuboid distraction arthrodesis occurs in 20% of cases. The graft-calcaneus interface is the site that typically fails to heal [12]. The significant rotation and shear forces along the lateral column may contribute to this relatively high failure rate. Revisional arthrodesis of the calcaneocuboid joint is a reasonable option to alleviate pain and maintain correction without significant compromise of hindfoot motion [12,13]. Fixation of the distraction arthrodesis should address the forces contributing to nonunion. Locked plate techniques or cervical



Fig. 6. Medial approach to subtalar fusion. Exposure allows direct visualization of all three subtalar facets. Severe degrees of hindfoot valgus can be more easily corrected from this approach through medial bone resection and medial translation of the calcaneus.

H-plates are good options for stabilization. If there has not been a catastrophic hardware failure and loss of alignment, revision with cancellous bone grafting and augmentation or revision fixation generally leads to successful union [13]. With any lateral column procedure, the surgeon must assess the medial column for instability and supinatus, which will leave residual deformity and lateral column overload if not addressed.

Tarsal coalitions

Hindfoot coalitions often present with a painful dysfunctional flatfoot, marked lateral peritalar subluxation, and, occasionally, peroneal spasm. Resection of the coalition alone without addressing the lateral peritalar subluxation seldom results in favorable functional outcome (Fig. 7). Failure to address the lateral peritalar subluxation with coalition resection will leave the hindfoot subluxed and rarely results in complete symptom relief. The coalition as well as the lateral peritalar subluxation must be viewed together as the same dysfunctional syndrome, because both contribute to the discomfort patients experience. Moreover, removal of a middle facet coalition often destabilizes the hindfoot by loss of the medial talar support, contributing to further mechanical degeneration.

Reconstructive surgery after coalition resection requires the same preoperative evaluation as any revision surgery. Hindfoot arthrodesis is indicated for joints that are found to be clinically and radiographically degenerative. Confirmation with intra-articular local anesthesia further confirms which joints to include for arthrodesis. The author believes it is essential to spare the essential hindfoot joints from arthrodesis whenever possible in the younger patient. Rarely does an associated degenerative arthrosis accompany



Fig. 7. Results in a 19-year-old woman after resection of a calcaneal navicular bar. Marked residual lateral peritarsal subluxation is present. (A) Double calcaneal osteotomy and medial column stabilization spare the essential hindfoot joints and maintain a stable plantar grade foot (B).

a coalition in the younger patient. A triple arthrodesis should be reserved for only the most severe revision cases.

Subtalar arthroereisis

Subtalar arthroereisis is a widely used technique in correction of the flexible flatfoot. Little published evidence exists to document procedure-specific problems associated with subtalar arthroereisis. Pain and cyst formation have been reported with ultra-high molecular weight polyethylene products such as the STA-peg (Dow Corning Wright Corp., Arlington, Tennessee) [14]. In failed cases with sinus tarsi pain, subtalar joint arthrosis, or peri-implant cyst formation, an arthrodesis is the most appropriate revision [14]. For cases in which there is sinus tarsi pain and no degenerative findings in the subtalar joint, removal of the implant usually resolves the pain. Zarat and Myerson [15] reported on 43 patients (31 children and 12 adults) treated with implanted MBA prostheses (KMI, San Diego, California). Seven of 43 patients had sinus tarsi pain after surgery, and four (9%) required implant

removal. There were no cases of cystic peri-implant degeneration or conversion to subtalar arthrodesis. Furthermore, there have been no documented cases of deformity recurrence with implant removal. The complications associated with newer generation anatomically designed implants seem to show predictable results [16].

Summary

Failure of flatfoot reconstruction can occur in many ways. Revision surgery must address the residual deformity if one exists, restore strength and balance to the foot and ankle, and address persistent joint pain. Assessment of the talometatarsal axis, hindfoot alignment, and medial column insufficiency is critical in selection of the appropriate surgical procedure. Arthrodesis of joints that are degenerative and unstable will ensure that the symptom relief will mirror radiographic results.

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