18 Revision of Malunion and Nonunion After Hindfoot Arthrodesis

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Key Takeaway Points

- Revision hindfoot arthrodesis is challenging and requires an intimate understanding of the anatomy and biomechanics of the hindfoot, midfoot, and forefoot and the normal relationship and interaction between them.
- A wide variety of pathology and deformity can be treated with hindfoot arthrodesis. It is critical to understand the underlying pathology that led to the index procedure, as this will likely be the key to the cause of failure and the plan for a successful revision.
- The goal of revision should be to obtain a well-balanced, plantigrade foot with a solid fusion. Many surgical reconstruction options are available. Surgical planning must be individualized based on the underlying pathology and the type and degree of deformity present.
- Successful management of hindfoot nonunions requires medical optimization of the patient; meticulous debridement of the pseudoarthrosis down to healthy, bleeding bone; a rigid internal fixation construct for mechanical stability; and biologic augmentation with bone graft or substitute.
- The goal of hindfoot malunion reconstruction is to achieve a plantigrade foot. This often involves complex osteotomies with bone blocks and/or wedges, as well as osteotomies or arthrodeses through the midfoot and forefoot to achieve a balanced foot.
- Literature is scarce to guide treatment in these difficult scenarios. Success can be achieved through precise surgical planning and surgical technique while respecting the basic principles of deformity correction, bone healing, and internal fixation.

Introduction

Hindfoot arthrodesis is a time-honored procedure for deformity correction that has been well documented and accepted in the orthopedic literature for almost 100 years [1, 2]. Originally used for the treatment of clubfeet and paralytic deformities

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caused by polio, the methods and indications have vastly expanded over the years. Current indications include a wide range of pathologic conditions including post-traumatic arthritis and deformity, inflammatory arthropathies, neurologic disorders, congenital abnormalities, and adult acquired flatfoot deformity (AAFD).

While hindfoot arthrodesis remains a powerful tool for deformity correction that generally produces satisfactory results, it is technically demanding, and complications are not uncommon. The most common cited complication after hindfoot arthrodesis is nonunion. Rates vary in the literature, but isolated subtalar arthrodesis has nonunion rates as high as 20% [3–7]. Contemporary series for triple arthrodesis have nonunion rates up to 23% [6, 8–13]. Isolated calcaneocuboid arthrodesis has nonunion rates that can approach 30% [14]. In general, nonunion rates have decreased over the years with advances in internal fixation. However, with the advent of computed tomography (CT) as the preferred method to evaluate bony consolidation, nonunion rates may be underestimated in the literature.

Although nonunion rates have decreased with modern internal fixation techniques and biologic augmentation, malunion in an overcorrected or undercorrected position continues to be a significant challenge [15]. In their early review of 80 triple arthrodeses, Angus and Cowell noted residual deformity in 62% of feet postoperatively [8]. Wilson et al. showed that 14 of 300 feet undergoing triple arthrodesis had poor positioning, necessitating additional procedures to achieve correction [11]. Manoli's review of triple arthrodesis results found a malunion rate of 6%, with 2 varus and 2 valgus malunions out of 63 procedures [16].

Haddad et al. reviewed the causes for failure of 29 patients undergoing revision triple arthrodesis and found that the failed index arthrodesis produced multiplanar deformity necessitating systematic correction [17]. The most common deformity was equinovarus with or without rocker bottom deformity (10 feet), followed by hindfoot varus (8 feet), hindfoot valgus (5 feet), and rocker bottom deformity alone (2 feet) [17]. Successful revision was able to be achieved in 87%. Hindfoot arthrodesis remains a technically demanding procedure with less than ideal outcomes. Complications can be minimized at the time of index procedure with careful preoperative planning, meticulous surgical technique, critical intraoperative assessment of the correction clinically and radiographically, and rigid internal fixation.

Patient Evaluation

The evaluation of a patient with pain and/or deformity following hindfoot arthrodesis begins with a thorough history. Understanding the reason for the index procedure is extremely important and may provide insight to the reason for failure. A pertinent medical history should be taken, focusing on factors that may predispose to complications, such as smoking status, diabetes, neuropathy, peripheral vascular disease, and nutritional status. These issues must be optimized prior to proceeding with surgical reconstruction.

Physical exam begins with a critical evaluation of patient alignment, not only of the hindfoot but proximally and distally as well. Standing evaluation may reveal any gross deformity of the hindfoot in varus or valgus. The entire lower extremity should be examined especially for angular and torsional deformity. It is not uncommon for foot deformity to be compensatory for more proximal abnormalities in the lower extremity. The presence of excessive tibia vara or femoral anteversion requires compensatory pronation of the foot and ankle in order for the foot to contact the ground in a plantigrade position [18]. Cavovarus deformities are often associated with external tibial torsion. Reconstruction and realignment of the foot without addressing the torsional deformity may cause marked external rotation of the foot in relation to the tibia. The patient should be counseled accordingly, and a rotational tibial osteotomy may be necessary to prevent this occurrence [19].

It is critical to understand the relationship of the hindfoot to the midfoot and forefoot. Hindfoot deformity correction and arthrodesis may unmask

a primary or compensatory deformity of the forefoot, which may be the cause of the patient's primary complaints after surgery. The forefoot should be assessed for residual plantarflexion (pronation) or dorsiflexion (supination) of the first ray in both the sitting and standing position. Insufficiency of the first metatarsal segment should be evaluated by checking for first cuneiform-metatarsal joint hypermobility or instability. Residual forefoot deformity often has to be addressed at the time of hindfoot revision to help ensure a satisfactory result.

Gastrocnemius tightness is critical to assess via Silfverskiold testing. If no attempt at a triceps surae lengthening procedure was performed at the index procedure, or if intervention was attempted but the patient still lacks adequate ankle dorsiflexion, great consideration must be given to a lengthening procedure at the time of revision. This will allow for optimal restoration of the anatomy of the hindfoot while reducing midfoot and forefoot pressures [20]. Furthermore, it addresses an underlying problem that was likely a main driver of the initial deformity in the first place.

Careful neurovascular examination is also an essential part of the evaluation. Muscle motor testing is performed to examine for weakness or overactivity that may drive deformity. The skin, capillary refill, and pulses are assessed for evidence of vascular deficiency. Finally, all previous surgical scars are noted, as these will often dictate placement of incisions at time of revision.

Imaging begins with standard weight-bearing foot and ankle series. The arthrodesis sites are inspected for bony consolidation. The adequacy of internal fixation type and technique should be heavily scrutinized. Adjacent joints of the midfoot and ankle are evaluated for degenerative changes.

Standard foot and ankle radiographic parameters are used to assess for residual deformity and malunion. Special attention should be given to talocalcaneal and talo-first metatarsal angles on both anteroposterior (AP) and lateral radiographs, as well as talonavicular coverage.

In the revision scenario, CT is an invaluable resource for preoperative planning. CT scanning is more powerful for identifying bony consolidation at arthrodesis sites when compared to standard radiographs [21]. Weight-bearing CT scan, when available, is also an excellent method to assess three-dimensional alignment, with higher reliability than standard radiographs [22] and non-weight-bearing CT [23].

Surgical Techniques

Once a thorough clinical and radiographic evaluation has been completed, cause for failure is identified, and a surgical plan is designed and implemented. The goal of revision surgery is to achieve a well-balanced, plantigrade foot with restoration of the normal relationships of the hindfoot to the midfoot and forefoot. Reconstruction necessitates an individualized approach based on the type and degree of deformity, patient activity, and expectations. Given the wide variety of underlying pathology in this patient population, there is no one "cookbook" approach to surgical reconstruction. General principles and considerations to achieve success in these challenging scenarios will be discussed further in the coming sections.

Nonunion

Nonunion is generally defined as failure of osseous bridging at the arthrodesis site after 6 months. Recent research has only just begun to evolve this definition and its consequences on patient outcome. While it is clear that CT is the modality of choice for assessing nonunion [21], defining and quantifying the amount osseous bridging at the nonunion site still needs exploration. Glazebrook et al. have shown that patient outcomes increase if there is 25–50% of osseous bridging seen on CT scan, versus those with 0–25% of bridging. Recently, it has also been confirmed that failure to achieve arthrodesis leads to a decrease in patient-reported outcomes compared to those patients who achieve a solid fusion [24]. Based on this limited evidence, an algorithm for managing patients with suspected nonunion can be fashioned (Fig. 18.1).

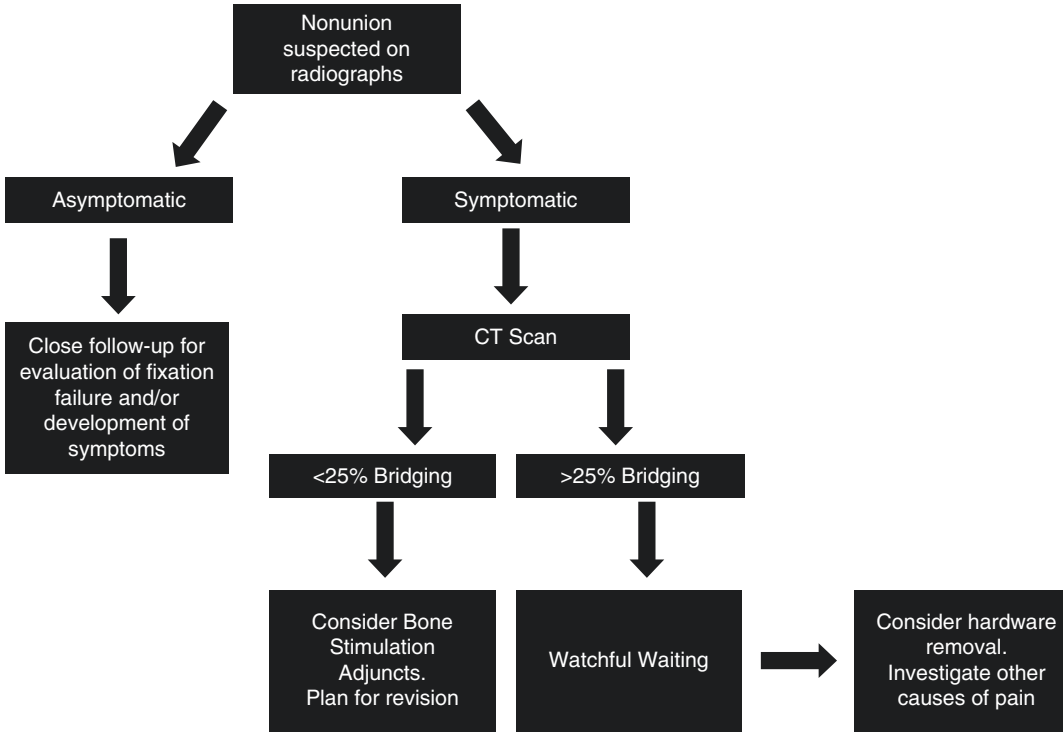

Fig. 18.1 Algorithm for management of hindfoot nonunions

If the patient has a symptomatic nonunion necessitating revision and the foot is well aligned, the decision-making becomes relatively straightforward as the only goal is to achieve a solid fusion to reduce pain and instability from pseudoarthrosis. Basic principles of bony healing must be considered to decipher the cause of the nonunion. Failure of bone healing can be broken down into insufficient biologic healing potential, inadequate fixation and mechanical stability, infection, or a combination of these factors. It should be emphasized again that an attempt should be made to optimize the patient's health status with regard to risk factors for nonunion prior to proceeding with surgery.

The site of nonunion is taken down and then meticulously debrided of all fibrous tissue. A combination of curettes, rongeurs, and osteotomes is used to manually scrape the nonunion site down to healthy, bleeding bone. Manual removal of all tissue is preferred over using a saw or burr, in order to preserve as much bony anatomy as possible and to prevent heat necrosis. As the joint surfaces are debrided, the bone stock must be critically evaluated. Achieving healthy opposing bony surfaces may create large voids and gaps that should be filled with grafting material. In the case of severe bone loss, structural allograft may be necessary, so the joint can maintain appropriate length and not lead to deformity through shortening of the medial or lateral columns.

Once the articular surfaces have been denuded of all remaining non-osseous tissue, the arthrodesis is prepared by drilling multiple holes through the subchondral bone using a small drill or K-wire. In nearly every revision scenario, biologic augmentation is used to increase odds of union. Proximal tibia autograft is an excellent choice for bone graft in the revision scenario; however, a variety of bone graft substitutes are available for use. Bone graft or substitute is then packed into the arthrodesis site, and the joint is reduced into the desired position and held with provisional fixation. It is critical to ensure that the joint surfaces are opposed with no gaps.

Rigid internal fixation is mandatory. Compression screws are used across the joint surfaces if possible. Positional screws should be used if compression will lead to relative shortening across the joint and lead to deformity. Screw tracts can be reused by utilizing larger-diameter screws than were used at the primary arthrodesis. This can be especially helpful for revision of the subtalar joint. At the surgeon's discretion, additional stability can be obtained through neutralization plating. A variety of anatomic non-locking and locked plates are available, which can be particularly helpful for the talonavicular and calcaneocuboid joints. If there is any question about the quality of fixation, more hardware should be added to the construct to improve stability (Figs. 18.2 and 18.3). Postoperative protocol includes strict non-weight-bearing and immobilization in a boot or cast at the surgeon's discretion. Weight-bearing status may be progressed once there is evidence of healing on radiographs, usually between 8 and 12 weeks. The surgeon should error on the side of longer weight-bearing status if severe bone loss required significant structural grafting.

Infection should always be on the differential as the cause of a suspected nonunion. If the clinical suspicion is low or equivocal for infection at the time of revision, cultures should be sent from the pseudoarthrosis material, and revision can proceed as planned. If the intaoperative cultures return positive results unexpectedly, infectious disease should be consulted for targeted intravenous antibiotics to suppress the infection until a stable fusion can be obtained. Once bony consolidation has been confirmed postoperatively, fixation may be removed in order to eradicate any potential nidus for deep infection.

If the clinical picture is obviously consistent with an infection preoperatively (erythema, draining purulence, etc.), thorough debridement and removal of hardware are warranted. Antibiotic-laden bone cement can be used at the time of debridement to elute high-dose local antimicrobial therapy, as well as to relatively maintain the normal lengths and relationships of the hindfoot joints. Cultures should be taken at the time of surgery, and infectious disease should be consulted for targeted intravenous antibiotic management. Once the infection has been cleared, removal of the antibiotic cement and revision arthrodesis can be performed, usually 3–6 months after initial debridement.

Malunion

Surgical planning in the malunion scenario is much more complicated. It deserves mention that prevention of a malunion through good surgical planning and technique is the best way of handling this situation. The general principles for alignment during primary hindfoot arthrodesis will be discussed briefly. At the time of index procedure, the surgeon must have a good understanding of the underlying pathology causing arthritis and deformity. This allows appropriate planning for additional maneuvers or procedures to fully address the deformity and balance the foot. Deformity should be approached systematically from proximal to distal with the goal of achieving a foot that is balanced and plantigrade. Correction begins with restoration of hindfoot alignment with placement of the calcaneal tuberosity in neutral to slight valgus position beneath the long axis of the tibia. Proper reduction of the talus on the calcaneus is critical to restore their normal relationship. The talar head should rest in line with the medial border of the anterior process of the calcaneus. Too wide of a talocalcaneal angle on the AP and lateral views allows for plantarflexion and medial deviation of the talus, leading to dorsal-lateral peritalar subluxation. The opposite is true with hindfoot parallelism, in which the talus is not divergent with the calcaneus on the AP view and is too horizontal on the lateral view, leading to plantar-medial peritalar subluxation.

Attention is then drawn to reduction of the navicular on the talus to provide adequate talonavicular coverage. Finally, the axis of the talus should point in line with the first metatarsal axis on both the AP and lateral views (Fig. 18.4). Attention to these basic principles in both the primary and revision setting will lead to optimal patient outcomes. Unfortunately, especially in

Fig. 18.2 (**a**, **b**) Radiographs of a 44-year-old male who underwent triple arthrodesis and developed a symptomatic nonunion. (**c**) CT scan showing lack of osseous bridging at the subtalar and talonavicular joints. Calcaneocuboid joint was also involved. (**d**, **e**) Radiographs following revision of all three joints with proximal tibial autograft. Modified Lapidus procedure was used to correct residual hindfoot varus due to instability of the medial column

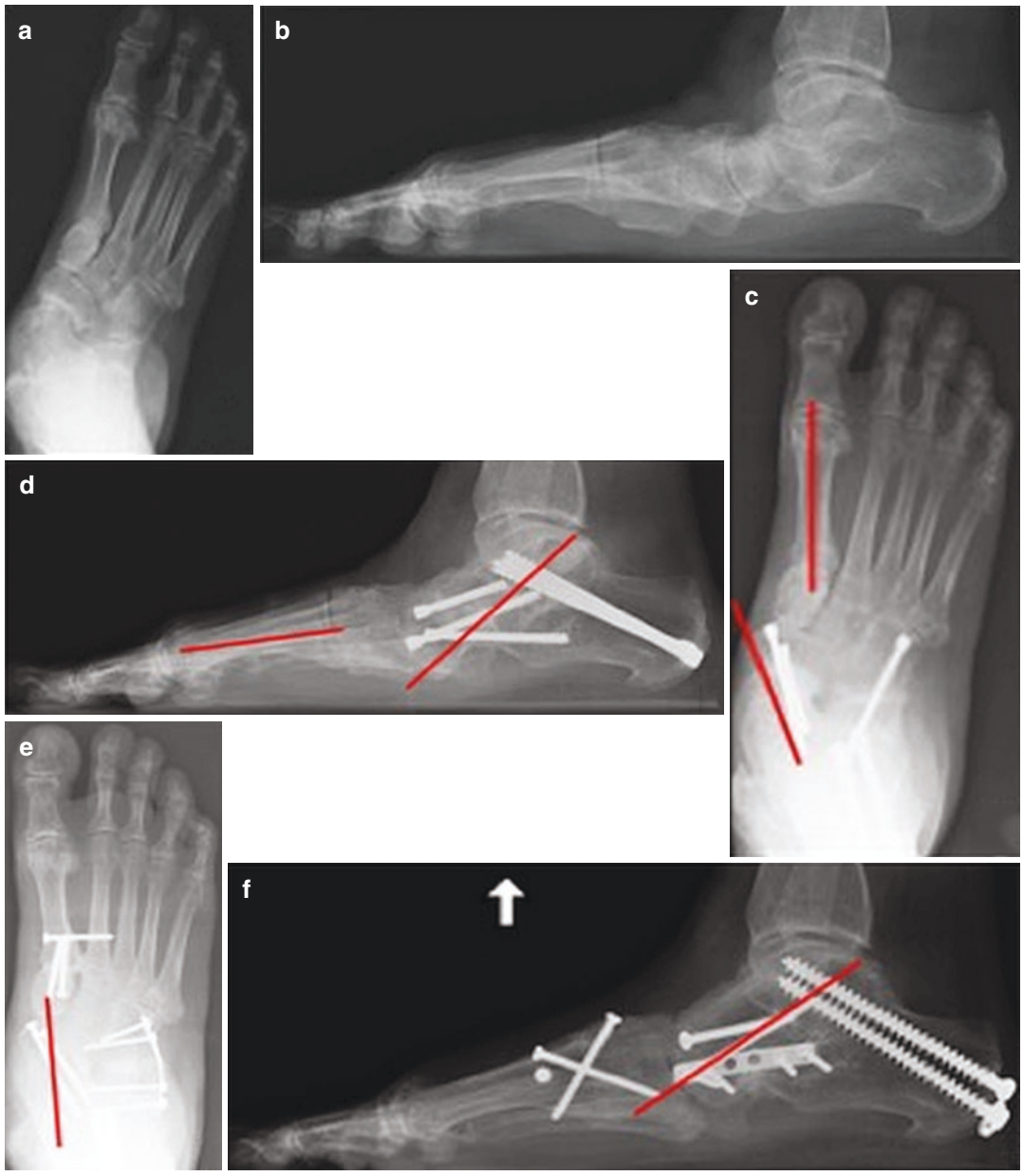

Fig. 18.3 (**a**, **b**) Patient was evaluated for rigid flat foot deformity. (**c**, **d**) He was treated by an outside surgeon with a triple arthrodesis. Note that he was nearly fused in situ with very little correction. He developed painful nonunions and was unhappy with the continued deformity of his foot. (**e**, **f**) He underwent revision triple arthrodesis. Note the improvement in talonavicular coverage and talofirst metatarsal angles. There is some residual plantarflexion deformity of the talus on the lateral view. Residual forefoot varus was treated with a first metatarsalcuneiform arthrodesis and a first to second metatarsal arthrodesis to restore forefoot balance

Fig. 18.4 Proper hindfoot double arthrodesis technique (**a**, **b**). A patient with severe rigid flatfoot deformity. (**b**, **c**) Status post triple arthrodesis. Note the significant improvement in talocalcaneal angles, talar coverage, talo-first metatarsal angles, and calcaneal pitch

revision scenarios, the path to achieving the normal relationships above is not always straightforward, and multiple options are available based on the type and magnitude of deformity.

Hindfoot Varus/Valgus

The first step in correction of a hindfoot deformity is to address equinus based on results of Silfverskiold testing. Most commonly, the gastrocnemius is the source of the equinus and can be reliably improved with a gastrocnemius recession. If equinus does not improve with the knee flexed, tendoachilles lengthening is performed, usually through a percutaneous hemisection technique. If the equinus is not addressed, it is often impossible to correct and unwind the deformity in the hindfoot.

The primary deformity in the hindfoot can be simplified into varus and valgus. Again, critical analysis of the etiology for the index procedure allows the surgeon to understand the underlying deformity to develop a precise surgical reconstruction plan for correction. Primary rigid hindfoot varus deformity may be generalized into neurologic, post-traumatic, congenital, and idiopathic [25]. Neurologic causes include hereditary motor and sensory neuropathies (MNSN), cerebral injury from stroke or traumatic brain injury,

and anterior horn spinal cell disease or spinal cord lesion. Calcaneus and talus fracture malunion are common causes of post-traumatic hindfoot varus. Congenital deformities include tarsal coalition, residual clubfoot, and intrinsic abnormal morphology in the architecture of the calcaneus and subtalar joint [26]. As discussed previously, hindfoot varus can be compensatory for external tibial torsion. Varus hindfoot malunion can cause lateral border overload with painful callosities or even stress fractures, peroneal tendon damage, lateral ankle instability, and varus tibiotalar arthritis.

The simplest way to address varus malunion is to perform an osteotomy through the tuberosity of the calcaneus. This can be a lateral translational osteotomy, laterally based closing wedge osteotomy, or a combination of the two. In severe deformity, trying to correct the varus deformity through a tuberosity osteotomy alone may not provide the needed correction. An osteotomy through the talocalcaneal fusion mass can also be performed, as described by Haddad et al. [17]. This is a laterally based closing wedge osteotomy that is performed at the level of the subtalar joint and is a powerful tool and our preferred method for hindfoot varus correction. Furthermore, other operative considerations may have to be considered based on the underlying anatomy. This is not uncommon in post-traumatic reconstruction, especially where the sequelae of trauma to the calcaneus or talus lead to hindfoot arthrodesis "in situ" without restoring the normal anatomy at the time of index open reduction and internal fixation (ORIF) or subsequent first arthrodesis. Hindfoot varus due to medial collapse malunion of the talar neck, for example, may require medial column lengthening procedure in addition to a valgus-producing hindfoot osteotomy to restore balance to the foot (Fig. 18.5).

In the case of calcaneal malunion sequelae, correcting hindfoot varus without addressing the lateral wall blowout would lead to continued subfibular pain and impingement, and a lateral wall exostectomy must be performed. If ankle range of motion (ROM) and impingement are an issue due to loss of calcaneal height, this may also need to be addressed with bone block or structural allograft. In the case of neuromuscular deformity, various soft tissue procedures, such as peroneus longus to brevis transfer and tibialis posterior tenotomy or transfer, may be needed to remove the driving forces of the initial deformity. These additional considerations add to the complexity and technical demands of the case, but have the best chance of restoring optimal patient outcomes.

The most common cause of a rigid hindfoot valgus deformity necessitating hindfoot arthrodesis is adult acquired flatfoot deformity (AAFD). Other causes of hindfoot valgus deformity include tarsal coalition, inflammatory arthropathies, cerebral palsy, and traumatic injuries to the talus, calcaneus, Chopart, and midfoot joints. The most common scenario for revision of hindfoot valgus nonunion is the undercorrection of a rigid adult acquired flatfoot deformity. Residual hindfoot valgus may cause laterally based pain from subfibular impingement or fibular stress fracture. Furthermore, with the hindfoot laterally positioned under the weight-bearing axis, deltoid ligament strain and attenuation can occur leading to rapid deterioration of the tibiotalar joint. The simplest method to correct this deformity is to perform a medial displacement osteotomy through the tuberosity of the calcaneus. However, this is usually not adequate depending on the underlying deformity. The subtalar fusion can be osteotomized, and hindfoot position can be restored through lateral opening or medial closing wedge. Medial translation through the osteotomy may have to be performed as well. In some instances, the subtalar joint has intrinsic lateral translation (Fig. 18.6). Failure to translate the osteotomy medially predisposes the patient to continued subfibular pain and impingement.

Forefoot Abduction/Adduction

Forefoot abduction/adduction deformities can be corrected through the power of the Chopart joint, with the goal being to balance the medial and lateral columns of the foot. Relative shortening of the lateral column compared to medial column will lead to forefoot abduction, as is commonly

Fig. 18.5 (**a**, **b**) Patient was evaluated following a talar neck fracture malunion with collapse into varus. (**c**, **d**) Reconstruction was performed with triple arthrodesis, utilizing a bone block through the talar malunion to restore medial column length

seen in adult acquired flatfoot. Shortening of the medial column, such as with talar neck fracture malunion, will lead to forefoot adduction (Fig. 18.4). In the case of a malunited Chopart fusion, abduction of the forefoot can be corrected by medial closing wedge osteotomy through the fusion mass, while an adduction deformity can be corrected with a laterally based closing wedge osteotomy [17]. Rotation can also be used through this same osteotomy to help correct residual forefoot supination/pronation [17].

If the Chopart joint has yet to be fused, arthrodesis of the talonavicular joint, with or without the calcaneocuboid joint, will lead to adequate correction with attention to re-establishing talonavicular coverage and talo-first metatarsal angles (Fig. 18.7).

Midfoot

When revising the hindfoot malunion, careful attention must be given to the midfoot's contribution to the patient's pain and deformity. Adult acquired flat foot deformity, for example, is not infrequently accompanied by arthritic changes in

Fig. 18.6 CT scan showing intrinsic lateral translation of the patient's native subtalar joint

the midfoot as the dorsal aspects of the joints collapse in compression and the plantar midfoot gaps under tension. This may lead to sag through the TMT joints or naviculo-cuneiform joints, which can be addressed by including the affected joints in the arthrodesis.

Forefoot Pronation/Supination

Correction of hindfoot deformity through revision arthrodesis will often unmask a forefoot deformity that, left untreated, will lead to unsatisfactory results. Care must be taken with any hindfoot arthrodesis procedure to evaluate and correct forefoot deformity to achieve proper foot balance. After correction of hindfoot valgus, there is often elevation of the first ray (supination) that must be addressed. If there has been a previous Chopart fusion, an internal derotational osteotomy can be performed through the Chopart joint [17]; however, it may be easier and more preferable to address the deformity through the midfoot. This can be achieved through a dorsal opening wedge osteotomy of the medial cuneiform (Cotton osteotomy). Another reliable method to bring down the first ray is first tarsometatarsal arthrodesis. The first metatarsal can be translated plantarly on the medial cuneiform to stabilize the first metatarsal segment in a plantarflexed position. This is especially helpful in adult acquired flat foot, where medial column insufficiency through the first TMT joint is often one of the underlying deformities.

After correction of a hindfoot varus deformity, residual pronation of the forefoot often must be addressed. A dorsiflexion osteotomy of the first metatarsal can be performed to bring the first metatarsal segment up. A dorsiflexion arthrodesis of the first TMT joint is another powerful tool to stabilize the medial column. Addressing the forefoot deformity at the midfoot or forefoot level allows much more precise fine-tuning of the deformity that is much more difficult to achieve more proximally through Chopart joint.

Finally, the surgeon needs to realistically judge the amount of surgical trauma and operative time necessary to achieve complete correction. In complex revision scenarios, attempting to reconstruct and balance the entire foot may be too much to do in one sitting. A staged correction may be prudent in an attempt to decrease wound and infectious complications.

Results

There is scant evidence to guide treatment for revision hindfoot arthrodesis, with only a few case series in the literature. Stephens and Saleh were of the first to describe a technique for revising triple arthrodesis [27]. In this series, a crescenteric calcaneal dome osteotomy was used to provide multiplanar correction in five patients, one with hindfoot valgus due to pes planus and four with equinovarus due to clubfoot or polio. Although very limited numbers, they reported 100% satisfaction with no complications.

Haddad et al. presented the results of 28 patients who underwent revision for failed triple arthrodesis [17]. A systematic approach was used to correct deformity from proximal to distal. Hindfoot valgus was corrected with a medial dis-

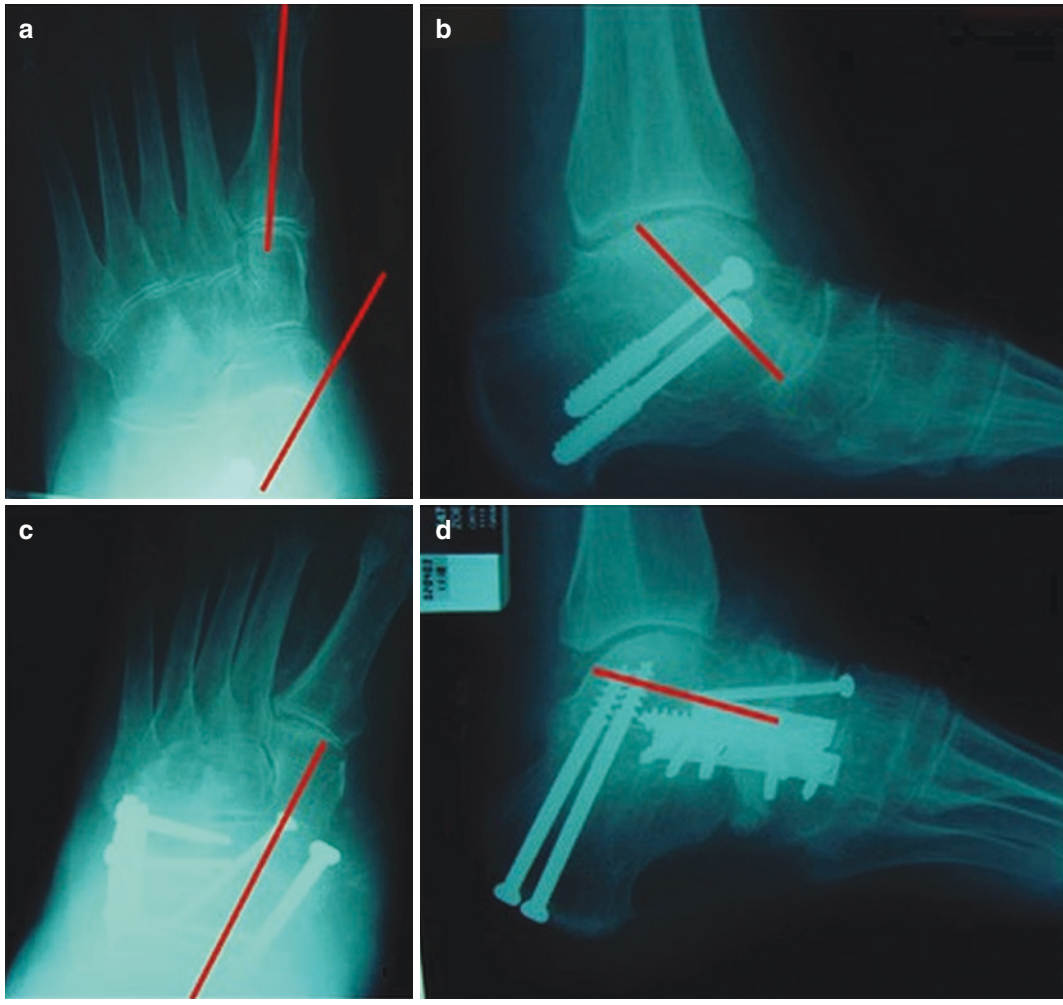

Fig. 18.7 (**a**, **b**) Patient was seen for evaluation of continued pain and deformity following in situ fusion of the subtalar joint for adult acquired flat foot. Note the dorsal-lateral peritalar subluxation allowing for significant forefoot abduction. (**c**, **d**) Correction necessitated revising the subtalar fusion and adding Chopart joint fusion with grafting of the lateral column to significantly improve forefoot abduction

placement calcaneal osteotomy, while hindfoot varus was addressed with either a lateral closing wedge osteotomy through the subtalar joint or a lateral closing and translational osteotomy through the calcaneal tuberosity. Forefoot supination/pronation deformities were corrected with transverse osteotomy through the transverse tarsal fusion mass and derotation to bring the forefoot plantigrade. Medial or lateral closing wedge osteotomies through the fusion mass were also used to treat forefoot abduction or adduction, respectively. Finally, rocker bottom deformity was revised with plantar closing wedge osteotomy. Following reconstructions, the American Orthopaedic Foot & Ankle Society (AOFAS) hindfoot scores improved on average from 31 to 59, with average satisfaction rated as 7.8 out of 10, and all patients saying that would have the operation again. They reported four (14%) major complications: one patient requiring debridement and three weeks of IV antibiotics for deep infection and symptomatic malunion in three patients necessitating repeat osteotomies.

Another analysis of 21 patients with rheumatoid arthritis and a failed triple arthrodesis showed that 12 of the failures (57%) were due to

a misjudgment in surgical technique [28]. They reported an 86% fusion rate with complications including two valgus malunions, one distal fibular stress fracture, and two superficial infections.

Finally, Toolan presented the results of five patients treated with a biplanar osteotomy through the midfoot to correct rocker bottom deformity after failed triple arthrodesis. One hundred percent satisfaction was obtained with an average increase in AOFAS hindfoot score from 33 to 70 and statistically significant improvement in all radiographic indices measured [29].

There are multiple surgical options when undertaking revision hindfoot arthrodesis. Surgeons should proceed with caution when attempting to correct multiplanar deformity through single osteotomies. More often than not, multiple osteotomies at different locations will be needed to achieve a plantigrade foot.

Summary

Correction of nonunion and malunion of the hindfoot is challenging. Prior to embarking on surgical revision, the surgeon needs to identify the underlying pathologic process and critically evaluate the deformity clinically and radiographically. Good results can be expected if restoration of normal relationships between the hindfoot, midfoot, and forefoot can be obtained to achieve a balanced foot. Complications can be minimized with meticulous surgical technique and rigid internal fixation. The literature is sparse to guide operative intervention. More research is needed to elucidate outcomes for these complex revision scenarios.

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