Role of Arthrodesis in Adult-acquired Flatfoot Deformity

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ABSTRACT
Adult-acquired flatfoot deformity (AAFD) is composed of multi-structure problems. Failure of tendons, capsular, and other ligamentous structures lead to significant deformity and disability. Several therapeutic approaches are used to treat this disease. Arthrodesis reconstruction type procedure was raised as a satisfactory operation with high patient satisfaction. Ability to reduce most severe and fix deformities made it a procedure of choice in dealing with advance stage AAFD. Malunion, nonunion, lateral wound breakdown, and adjacent joint osteoarthritis are leading problems associated with this operation. However, there are some situations that patient will be best undergone these operations. Realigned triple arthrodesis along with its modifications are currently wide-accepted treatment for rigid arthritis flatfoot. Severe flexible AAFD and failed flatfoot reconstruction while choosing patients properly are also possible indications to treat with the fusion techniques. Lastly, some specific patient factors (age, morbid obesity, preexisting degenerative joint disease, and neuropathic patients) could be important factors to influence type of operations.

Keywords: Adult-acquired flatfoot deformity, Arthritis, Deformity, Double arthrodesis, Flatfoot, Fusion, Modified double arthrodesis, Posterior tibial tendon dysfunction (PTTD), Triple arthrodesis.
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Figs 1A to D: Typical deformities in AAFD patient (left side): (A) Heel valgus with too many toe signs; (B) Midfoot abduction; (C) Flattening of the medial longitudinal arch; (D) Impingement of lateral ankle

screws to use.9,10 Next step, TN joint should be reduced by inversion of midfoot and plantarflexion of first ray to reverse deformities. Either plate or compression screws is then used to fix the construct. Again, there are no consensus about fixations techniques.11 At last, CC joint should be examined for space. If it has a noticeable gap, then bone graft will have to be filled in order to avoid nonunion and shortening of fusion site.

Pell and colleagues12 reported medium-term follow-up study of 132 feet underwent triple arthrodesis to have a powerful ability of deformity correction, good satisfaction points (8.3/10), and acceptable postoperative modified American Orthopaedic Foot and Ankle Society (AOFAS) score (60.7/94). However, rate of adjacent ankle osteoarthritis had increased significantly, although patient satisfaction was not associated with the presence of arthritis. They concluded that triple arthrodesis is effective in relieving pain and decreasing functional deficits secondary to various etiologies and deformities. Czurda and associates in 2009 reported the similar outcomes in retrospective study of 20 patients. They found significant improvements in AOFAS score (average 51 points). Seventy-five percent of the patients had no or only slight pain. Nearly, all the patients were satisfied with the result of the surgery.13

Wound complications are the most common complication in early postoperative phase. Most of wound problems are from lateral incision because it is the tension side after corrections. In effort to reduce this problem, Jeng and colleagues14 treated 17 patients who had a rigid hindfoot valgus deformity with triple fusion through a single medial incision. There were no wound complications but CC fusion was not completed in two patients regarding exposure. Adequate CC joint exposure and difficulty in fixation could be limitation of this technique. Röhm and associates reported mid- to long-term results of 84 patients underwent TN and ST joint fusion through a medial incision (modified double arthrodesis). Most of the patients (90.5%) can maintain the fusion construct until the last follow-up. Neither major wound complications nor need for further CC joint fusion was reported.15

In mid- to long-term postoperative phase, the problems will be shifted to limitations in an ambulation. Due to decreased overall motions, patients will have gait problems with walking inclines, accommodating uneven ground, and stair climbing.16 Adjacent joint osteoarthritis is another major complication related to triple fusion. In some series, rate of osteoarthritis goes up high to nearly half of all patients.17,18 Increased stress to ankle and midfoot secondary to the stiffness from triple fusion construct is accounted for the accelerated wear of joints.

To deal with the late problem as osteoarthritis, many investigators shared an idea of fusing fewer joints to attain the deformity correction while preserving some hindfoot motions. In 1997, Astion and his colleagues conducted a cadaveric study about hindfoot motion after selective arthrodesis. They found that any combination of simulated arthrodesis that included the TN joint will lock the motion of the remaining joints to about 2°. As a result, they concluded that the TN joint is the key joint of the triple joint complex. The TN joint had the greatest range of motion, and simulated arthrodesis of this joint essentially eliminated motion of the other joints of the complex.19
Mann and Beaman reviewed 24 patients underwent double arthrodesis. The overall satisfaction rate was 83 and 76% of patients having good and excellent results. Adjacent osteoarthritis was observed in many patients, but most patients were asymptomatic. Nonunion of TN joint is the most complication in their study.20 Clain and Baxter also reported 75% of their patients (16 feet) to have excellent and good results following double arthrodesis operation. Progressive arthritis of the ankle was seen in six patients and of the naviculocuneiform joint in seven.21 These investigators recommended this procedure for patients with advanced deformities in which arthritis focus on only transverse tarsal joint and a passively correctable non-arthritic ST joint. Thus, arthritis of ST joint should be compelling contraindication for this procedure.

Several surgeons found that it would be very hard to find the case without ST joint arthritis in such a later stage of rigid flatfoot.22 With this in mind, they recommended to include ST joint in fusion procedure. Moreover, they pointed out that CC should be left unfused. Sparing the CC joint has several advantages. It reduced the operative time and the risk of nonunion.23 Preserved CC joint provides some movement and did not further shorten lateral column length and thereby diminished the loading on adjacent joints which may lead to arthritis.12,29

Knupp et al.24 described a retrospective review of 32 feet underwent modified double fusion through a medial approach. Fusion was achieved in all feet at a mean of 13 weeks and no wound complications. Fusion construct remained stably unchanged at average 2-year follow-up time. Similar early term results were reported by Brilhault and Sammarco. Brilhault and colleagues stated that significant radiographic improvements were achieved in all of their patients while no report of major wound complications and an asymptomatic CC joint.25 Sammarco and his groups showed a marked AOFAS Ankle-Hindfoot Scale improvement in the study 44.7 preoperatively to 77.0 postoperatively (p < 0.01). Moreover, their patients experienced improvements in pain, function, cosmetic, and shoe wear.23 To date, there are no studies that report long-term outcomes with this selective fusion procedure. Longer follow-up times may need to prove the better results of this technique.

Recently, some studies were established to compare the results between traditional triple arthrodesis and modified double arthrodesis. DeVries and Scharer conducted a retrospective radiographic to compare these operations (40 cases, each 20 consecutives cases). Both groups demonstrated ability to reduce severe deformities and postoperative results were similar.26 In contrast, Burrus and his associates reviewed medical record of patients who had undergone either a modified double (n = 9) or triple (n = 7) arthrodesis for stage 3 flatfoot deformity. Interestingly, modified double fusion group had significant lower mean Foot and Ankle Ability Measure ADL score. All of triple arthrodesis patient achieved satisfactory union but modified double arthrodesis group had a union rate only 56%. The main limitation of this study was small number subjects. More population number will ensure the results.27 In 2020, the American College of Foot and Ankle Surgeons (ACFAS) had a consensus statement regarding TN and ST joint fusion in combination or in isolation for effective treating rigid flatfoot deformity. They concluded that this statement is neither appropriate nor inappropriate and decision to fuse which joints should be based on symptoms and magnitudes of deformity corrections (Fig. 2).28

**Severe Flexible AAFD**

Joint preserving procedure is currently in trend with treatment of stage 2 flexible flatfoot. Many combinations of bony and soft-tissue procedures were applied to get the best outcomes rather than just one isolated procedure. However, some surgeons advocated limited fusion techniques as their primary treatment. In hope of stable and reliable results, Cohen and Johnson proposed realignment ST arthrodesis as an effective treatment of the planovalgus deformity of posterior tibial tendon insufficiency. Union rates from their series was approaching 100%.29 Johnson et al. recommended ST arthrodesis combined with spring ligament repair/reefing and flexor digitorum longus (FDL) transfer to the navicular to treat stage PTID. Indication for their operation was the presence of a flexible planovalgus deformity without fixed forefoot varus or degenerative changes at the transverse tarsal joints. They believed that direct correction of ST joint was more predictable and durable than indirect correction through changing of musculotendinous pulled line axis (such as calcaneus osteotomy, LCL). Second, addition of the medial soft tissue reconstruction, including tendon transfer and TN capsule/spring ligament complex imbrication, provided additional correction of forefoot abduction and midfoot pronation, restored plantar flexor power at the ankle, and reduced the abnormal valgus alignment. The study results showed favorably outcomes as good as with flexor transfer combined with either calcaneal osteotomy or LCL.30

Severely compromised spring ligament could be another recommendation for selective fusion. Sometimes in severe case, there was not enough tissue for reconstruction or not strong enough for constructs. Some surgeons gave an idea of limited fusion instead of ligament reconstruction for better reliable alignment.31 Despite more predictable outcomes in severe flexible flatfoot patients, many investigators still aware of complications like nonunion. Latest study in 2018 was conducted to compare reoperation rates and complication rates following flexible joint-sparing reconstruction vs fusion procedures in flexible AAFD patients. Nonunion rate was higher in fusion group (16%), while flexible reconstruction group was only 4%. However, rates of reoperation for nonunion were similar between groups. This would reflect that most nonunion might be asymptomatic.32

**Failed Flatfoot Reconstruction**

While dealing with the case of previous failed operative treatment, the important things are to address the cause of failure and recognize what is exactly patient’s problems. Overall alignment should always be examined. If alignment is acceptable, it means that problem would be from nonunion sites or arthritic joints. Regarding degenerative joint disease, arthrodesis would have a role in this problem. Selective fusion of involved joint would be a solution. However, decision to fuse which joint should be based on severity, location of pain, and other patient factors (age, demand of patient, underlying). In the other case, nonunion should be repaired with or without bone graft.33

If malalignment is presented, every components should be checked. Forefoot, midfoot, and hindfoot including ankle or in combinations could lead to a potential threat. Depending on location shape of deformities and what was done prior, decisions can then be made regarding corrective osteotomy vs realignment fusion.
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Malalignment could be categorized into two types—undercorrection and overcorrection. About undercorrected group, the usual deformities are forefoot varus, midfoot abduction, and hindfoot valgus liked untreated flatfoot. Surgical options treating residual hindfoot valgus included medializing calcaneal osteotomy, ST arthroereisis, and ST arthrodesis. Hindfoot arthritis and its flexibility are factors to dictate choice of procedure.35

Residual midfoot abduction is corrected by LCL procedures. Both calcaneal opening wedge osteotomy (Evans) and CC distraction arthrodesis have the ability to accomplish this.35 Controversy still arise inappropriate indication for these procedures. Thomas et al. reported result in 27 feet underwent LCL procedures by comparing these techniques. Both operations showed significant improvements in radiographic parameters and postoperative AOFAS scores. But there was a concern about high rate of nonunion and delayed union associated with the CC distraction arthrodesis group.36

Focus on residual forefoot varus, first tarsometatarsal (TMT) arthrodesis and medial cuneiform opening wedge osteotomy (cotton osteotomy) are among top-notch procedures. Tarsometatarsal complex hypermobility is the key to select between these two procedures.35 “Plantar gap sign” (Fig. 3) as seen on lateral weight-bearing foot radiograph would suggest midfoot instability (hypermobility). If we could detect this situation or arthritis of midfoot, TMT fusion procedure is then more suitable operation. Although TMT arthrodesis had a bad reputation of high rate of nonunion (10–12%), some studies provided promising results.
Thompson and his colleagues conducted a retrospective study in 182 patients underwent modified Lapidus procedure or tarsometatarsal joint (TMTJ) arthrodesis as part of a flatfoot reconstruction. Their nonunion rate was as low as 4% and 2% revision rate. They believed that meticulous operative technique, proper prepared fusion site, rigid internal fixation, using local bone grafting, tending Achilles lengthening or gastrocnemius slides for equinus contractures, and postoperative immobilization are the key for their success.38

Minority of failed foot reconstruction case had an overcorrected alignment. The deformities typical look like a cavovarus foot. Every components of foot had to be analyzed as in the treatment of undercorrected cases.39 Most soft tissue problems, such as an overlengthening of the gastrosoleus complex, overtightening of FDL tendon transfer, could be solved by physical therapy. Hindfoot varus from excessive inferomedial translation usually well treated with various techniques of calcaneal osteotomy.39

Lateral foot discomfort is the chief complaint of overlengthening lateral column. Then, shortening lateral column procedures either through closing wedge osteotomy or shortening arthrodesis would be considered. Lastly, excessive planter flexed first ray from overcorrection medial column could pose a pain around first ball and sesamoid area. Dorsiflexion closing wedge osteotomy of midfoot would have a role for this condition. Otherwise, if the medial joint complex had an arthritis, realignment arthrodesis (dorsal closing wedge or superior translation) would be more appropriated.39

**Specific Patient Factors**

Several investigators believed that some patient’s factors would be a benefit from joint fusion procedure more than the others. Morbid obesity is one of the first factors to be concern. More weight means more load to reconstruction construct. Better stable construction would maintain correction of the deformity. A study by Nielsen et al. shown a worse outcomes with obesity [body mass index (BMI) > 30] but failed to make it statistical significant.40 Age is also an importance factor. Older patients always get along with comorbidities and sedentary lifestyles. Thus, these patients should undergo just only one definite surgery. Arthrodesis is a more reliable procedure and its short-term outcome is equally good as other operation.31 Preexisting degenerative disease from past injuries or other conditions should be better off with selective fusion in involving joints as joint-sparing procedure is unlikely to solve the problem. Lastly, patients with neuropathic deformity, such as Charcot arthropathy, should be strongly recommended to undergo arthrodesis type operation. These patients lose their protective sensation to protect themselves. Strong and durable reconstruction will be a preferable operation.44

**Conclusion**

Adult-acquired flatfoot deformity had a wide spectrum of disease. The symptoms range from minor pain with flexible deformity to fixed painful multiple directions deformities and arthritis. Thus, various treatments are proposed in order to get the best outcomes. Arthrodesis procedure and its variants have good reputations in sustained predictable results with irresistible short- to mid-term outcomes. In spite of this, their late major drawbacks including limitation in an ambulation due to joint stiffness and adjacent osteoarthritis make this procedure to be used as a salvaged operation. Every attempts should go toward joint-sparing procedures before proceed to fusion operations. However, arthrodesis procedures still play a main role in treating rigid arthritic flatfoot patients. Other possible indications for this operation are severe flexible flatfoot deformity, failed flatfoot reconstruction, and some specific patient factors (age, morbid obesity, preexisting degenerative joint disease, and neuropathic patients).

**References**


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