Medial Column Procedures in the Correction of Adult Acquired Flatfoot Deformity

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KEYWORDS
• Adult acquired flatfoot deformity • Cotton osteotomy • Forefoot varus
• Medial column osteoarthritis

KEY POINTS
• Forefoot varus is a common finding associated with the adult acquired flatfoot deformity (AAFD).
• Physical examination of the foot, when the hindfoot has been corrected to neutral, is the best method to determine if forefoot varus exists and whether surgical correction is needed.
• Forefoot varus owing to mild instability of the naviculocuneiform joint or the first tarsometatarsal joint is treated with a plantarflexion opening wedge osteotomy (Cotton osteotomy) of the first cuneiform.
• Forefoot varus owing to medial column osteoarthritis or significant instability is treated with arthrodesis of the involved joint(s) to restore the “tripod” of the foot.

Adult acquired flatfoot deformity (AAFD) is a global term that applies to patients with varying degrees of hindfoot valgus, forefoot abduction, and forefoot varus. Most commonly, a patient complains of medial hindfoot pain and swelling with a variable degree of progressive pes planovalgus. The most common cause of AAFD is posterior tibial tendon (PTT) dysfunction.1 Function of the PTT is critical because it contributes to the static stability of the foot along with the spring ligament complex.2 Failure of the PTT to maintain the arch of the foot can lead to progressive hindfoot valgus and collapse of the medial column through the first metatarsocuneiform joint (also known as the first tarsometatarsal [TMT] joint), the naviculocuneiform (NC) joint, and/or the talonavicular (TN) joint.2 Other etiologies of AAFD include pathology such as post-traumatic deformity, osteoarthritis, inflammatory arthritis, Charcot neuroarthropathy, and neuromuscular disorders.3,4 Numerous combinations of bone and soft-tissue...
procedures have been described to address the different types of pes planovalgus deformity without a clear consensus on a treatment algorithm.\textsuperscript{2,5–15}

**BACKGROUND**

The typical history given by a patient with an acquired flatfoot deformity secondary to PTT insufficiency is a progressive change in the shape of their foot over time. The patient describes increasing pain and difficulty with weight-bearing activities. Typically, there is no specific instance where the foot changed form, or “collapsed.”

Physical examination begins with an observation of the standing alignment of the foot and ankle to evaluate the extent of hindfoot valgus, midfoot pronation, and forefoot abduction. Assessment of neurovascular and motor function is performed to rule out other causes of tendon dysfunction and ensure that the remaining muscle function in normal. The PTT is examined with the patient seated by asking them to invert the foot while maintaining a plantarflexed and everted posture to the foot so as to reduce inversion by the anterior tibial tendon that may mask PTT weakness. This maneuver typically demonstrates weakness of the PTT compared with the contralateral side.

In the early stages of disease, deformity of the foot remains flexible and correctible; however, in later stages the deformity remains fixed. The best way to evaluate the ability to correct a foot deformity to a more normal posture is on seated examination. Hindfoot valgus is typically corrected through the subtalar joint by grasping the calcaneus with one hand and internally rotating the calcaneus while stabilizing the ankle and talus with the other hand. If the hindfoot can be corrected to a normal posture through the subtalar joint and the midfoot can be corrected through the transverse tarsal joint, then it is felt to be a correctible deformity. At this time, while holding the hindfoot in neutral, any gastrocnemius or soleus contracture can be assessed with the use of the Silfverskiöld test.

Persistent hindfoot valgus and collapse of the medial column eventually results in forefoot varus, which may be exhibited by significant first ray elevation or global forefoot varus at the transverse tarsal joint.\textsuperscript{16} Deformity through the medial column should be evaluated with the patient in the seated position. The hindfoot is placed in a “neutral position” by centering the navicular over the talar head.\textsuperscript{17} The deformity is confirmed by palpating the medial border of the foot and the relationship of the navicular tuberosity to the talar head. As the hindfoot is held in this position with one hand, the opposite hand is used to passively bring the ankle to neutral dorsiflexion by placing force on the plantar aspect of the fourth and fifth metatarsal heads. At this point, the relationship of the first and fifth metatarsals is evaluated by viewing the foot “head-on” to determine the degree of elevation of the first ray relative to the fifth ray which is known as the degree of forefoot varus (Fig. 1).\textsuperscript{18}

Stability of the first ray is assessed with the patient in a seated position by stabilizing the lesser four metatarsals with one hand and then using the opposite hand to manipulate the first metatarsal. The dorsiflexion and plantarflexion of the first ray in relation to the rest of the foot is assessed to determine if there is excessive motion or if there is pain or crepitus with range of motion.

In addition to the physical examination, radiographs play an important role in determining the etiology of AAFD as well as assessing the deformity of a patient’s foot. Weight-bearing radiographs of the foot and ankle should be obtained for proper evaluation. On a normal weight-bearing anteroposterior and lateral radiograph, the calcaneocuboid joint should be at the same level as the TN joint. With AAFD, the foot radiographs show the appearance of a short lateral column compared with the medial
column, with the TN joint approximately 3 to 5 mm distal to the calcaneocuboid joint. Additionally, the anteroposterior radiograph helps to quantify forefoot abduction through evaluation of the TN coverage angle. This is measured by determining the amount of the talar head that is “covered” by the navicular, with a smaller degree of coverage corresponding with increased forefoot abduction.

On the weight-bearing lateral radiograph, the medial column of the foot can be carefully evaluated. The lateral talo–first metatarsal angle, also known as Meary’s angle, is measured between the line drawn representing the longitudinal axis of the talus and that of the first metatarsal. Normal is considered measurements from +5 to −5 degrees. Measurements less than −5 degrees are considered to have pes planus. Another angular measurement that can be measured on a weight-bearing lateral radiograph is the calcaneal pitch. This is the angle formed by the intersection of a line drawn along the plantar surface of the calcaneus and a line drawn parallel to the ground. Normal measurement for calcaneal pitch is 10–30°, thus less than 10° would be considered abnormally flat (Fig. 2).

Fig. 1. Photograph comparing (A) forefoot varus deformity with the first metatarsal head elevated above the fifth metatarsal head in the coronal plane and (B) normal forefoot alignment.

Fig. 2. Lateral weight-bearing radiograph of a foot demonstrating Meary’s angle (normal +5° to −5°) and calcaneal pitch angle (normal, 10° to 30°).
In addition to angular measurements, the joints of the medial column should be carefully evaluated on the weight-bearing lateral radiograph. Instability at the TMT, NC, or TN joints may result in asymmetry at the joint where there may be a relative plantar gap at the joint space or subluxation. Further, the medial column joints may show evidence of degenerative change such as joint space narrowing, subchondral sclerosis, or osteophytes. Identifying the unstable or arthritic joint along the medial column is important because this information will help guide the surgical treatment plan if nonoperative modalities fail.

Nonoperative treatment for medial column deformity or instability with a foot orthosis may be helpful, especially if the patient has a flexible or correctible deformity as characterized on physical examination. A custom-molded, semi-rigid foot orthosis for arch support is posted at the medial heel and the lateral forefoot to help correct foot pronation and forefoot varus. If the forefoot varus is rigid, then an accommodative, semi-rigid molded orthosis with medial forefoot posting is used to support the forefoot in the varus posture. If these options are unsuccessful, or if the patient has a more rigid deformity that is not easily corrected with an orthosis, the patient can use a custom molded brace such as a plastic and leather composite lace up brace (ie, an Arizona brace) or a rigid ankle–foot–orthosis with a molded foot orthosis inside the brace.

For AAFD, there are numerous surgical options that include tendon repair, tendon transfer, osteotomies, fusions, and combinations of these procedures. The operative procedures chosen must address the etiology of the AAFD and, most important, must address all the components of the deformity. If the deformity is flexible or passively correctible on physical examination and not associated with degenerative joint disease, then a reconstructive option utilizing osteotomies can be considered. If the deformity is rigid or not passively correctible, then one must employ a triple arthrodesis (fusion of the subtalar, TN, and calcaneocuboid joints) to correct the deformity appropriately.

With flexible deformity, most commonly PTT dysfunction, the reconstructive procedure includes a medial soft tissue reconstruction that involves a flexor digitorum longus tendon transfer to the navicular to augment or replace the PTT in addition to repair or imbrication of the spring ligament if needed. Additionally, the gastrocnemius and soleus complex is addressed with lengthening as needed to decrease the hindfoot valgus force and resultant influence on the forefoot deformity. Reconstruction or repair of the medial soft tissue structures helps to restore function to the foot; however, the underlying flatfoot deformity would eventually result in attenuation and failure of the repair. As such, it is important to correct any underlying deformity with bony procedures.

Options for bony correction commonly include a medial displacement calcaneal osteotomy to primarily correct the hindfoot valgus deformity or a lateral column lengthening to correct forefoot abduction. However, these procedures do not address the forefoot varus component of the AAFD. Even a triple arthrodesis may not completely correct forefoot varus if the deformity is distal to the TN joint. Without appropriate correction of the flatfoot deformity, the patient retains some level of deformity and has altered biomechanics with excessive weight-bearing on the lateral border of the foot and possible overload of the deltoid ligament of the ankle.

Numerous options exist for correction of forefoot varus through the medial column. The appropriate choice is based on proper identification of the location of deformity and identification of abnormal or arthritic joints. The focus of this article is on two such medial column procedures: the Cotton osteotomy (plantarflexion opening wedge medial cuneiform osteotomy) and the first TMT fusion.
The Cotton Medial Cuneiform Osteotomy

In 1936, Cotton described a procedure to assist in correction of the flatfoot deformity that used an opening wedge medial cuneiform osteotomy to plantarflex the first ray. With this procedure, he theorized that the "triangle of support" would be restored to the foot and allow the patient to have improved function by restoring the mechanics of weight-bearing. Since Cotton’s original report, little has been written on the use of this medial cuneiform osteotomy as part of flatfoot deformity correction.

**Indications**

A plantarflexion opening wedge medial cuneiform osteotomy should be used as an adjunct to reconstruction of a flatfoot deformity. Primarily it is used to correct forefoot varus with elevation of the medial column where the deformity is located at the first TMT joint or the NC joint. This forefoot varus is typically identified preoperatively on physical examination and is further evaluated with preoperative weight-bearing radiographs (see Fig. 1; Fig. 3).

The Cotton osteotomy is a joint-sparing procedure; thus, the first TMT joint should be stable or have only mild instability on physical examination. Further, there should not be any radiographic evidence of joint abnormality such as plantar gapping on the lateral weight-bearing radiograph or findings of significant osteoarthritis. If the lateral x-ray demonstrates marked dorsal subluxation of the first metatarsal in relation to the medial cuneiform or if there are findings of arthritis, cuneiform osteotomy is contraindicated. In these cases, arthrodesis of the first TMT joint is indicated. Further contraindications to the Cotton osteotomy include deformity that is greater than what a 5- to 8-mm plantarflexion bone block can correct. In these situations, more proximal procedures such as reduction and fusion of the NC or TN joints are...
indicated. Additionally, a fixed forefoot deformity through the transverse tarsal joints should be addressed with correction at this more proximal level rather than through a cuneiform osteotomy.

Most commonly, the Cotton osteotomy is performed as a last step in surgical reconstruction of the AAFD. Typically, the other hindfoot osteotomies would have been completed and fixed in their corrected position. After the medial soft-tissue repair and tendon transfers are prepared for fixation, the static posture of the newly corrected foot is evaluated. The amount of residual forefoot varus is assessed both clinically and with a lateral intraoperative x-ray; and if significant deformity remains, it should be corrected to restore the “triangle of support.”

**Technique**

The patient is positioned supine on the operating room table for the flatfoot reconstruction procedure. A bump is placed under the ipsilateral buttock to internally rotate the affected leg and a tourniquet is placed around the thigh. If the surgeon elects to use an autograft, the donor iliac crest is prepped and draped along with the operative leg. Under tourniquet, a dorsal longitudinal incision is made over the level of the medial cuneiform joint (Fig. 4). The skin and subcutaneous tissues are carefully dissected down to the level of the extensor hallucis longus (EHL) and extensor hallucis brevis (EHB) tendons. The EHL is retracted medially and the EHB is retracted laterally. Care is taken to be sure the dorsalis pedis artery and deep peroneal nerve are lateral to the field of work. The dorsal portion of the medial cuneiform is exposed.

![Fig. 4. A dorsal longitudinal incision is used that is centered over the medial cuneiform. Care is taken to stay medial to the dorsalis pedis artery and deep peroneal nerve.](image)
At this point, the C-arm fluoroscopy is used to identify the mid-portion of the cuneiform. It is at this level that the osteotomy is performed (Fig. 5). A microsagittal saw is then used to create a transverse osteotomy from dorsal to plantar through the midportion of the medial cuneiform (Fig. 6). On lateral C-arm images, this tends to be at or just proximal to the level of the second TMT joint. The saw is used to cut the bone up to, but not through, the plantar cortex of the cuneiform. An osteotome is then used to propagate the cuneiform osteotomy in a greenstick manner. It is important to leave the plantar periosteum and ligamentous attachments intact so that the osteotomy does not risk displacement or distraction. That same osteotome is then pulled distally and used as a lever to plantarflex the first ray through the newly created osteotomy (Fig. 7). The foot is then evaluated both clinically and with lateral C-arm imaging to determine the amount of correction that is needed to restore Cotton’s “triangle of support” and the width of the osteotomy gap is measured. Generally, a 5- to 8-mm wedge of bone is needed to plantarflex the first metatarsal so that clinically and radiographically it rests in line with the fifth metatarsal head.

The graft is obtained next. A tricortical iliac crest wedge has been described, although many types of bone grafts may suffice, and it is surgeon’s preference whether to employ autograft or allograft. The graft is cut into a triangular wedge with a microsagittal saw to the appropriate size, so that the graft’s cancellous surfaces opposes the cancellous surfaces of the native cuneiform. The cortical surfaces of the graft should rest dorsally, medially, and laterally. A narrow osteotome is then used to lever open the graft site and the graft is gently impacted in place with a bone tamp. Fixation of the graft is the surgeon’s preference and may include a K-wire, a single cannulated screw, a compression staple, or a small plate (Fig. 8). The author’s preference is a single, 0.062-inch smooth K-wire for percutaneous fixation across the osteotomy, which is removed at 4 to 6 weeks. Some surgeons use no internal fixation. Recently, a wedge plate as well as a metallic wedge have been developed and marketed; however, we have no experience using these devices. The wounds are closed and the patient is splinted. The postoperative protocol may depend on the other concomitant procedures performed at the time of the Cotton osteotomy. Typically, the patient remains non-weight-bearing and casted for a total of 6 weeks from the time of surgery. At that point, assuming the radiographs show signs of
healing and the patient has no significant tenderness, the patient is allowed to bear weight in a protective boot. With standard progression, they begin weaning from the boot at about 10 weeks after surgery (Fig. 9).

**Results**

In his original article, Cotton stated that “the operation is simple, not painful, and . . . in the short series of cases done since I devised this operation, there has been no trouble in any.” More recent literature has supported this claim and shown the procedure to be straightforward and predictable, with minimal morbidity. In one.

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**Fig. 6.** (A) A transverse osteotomy is made through the midportion of the cuneiform using a microsagittal saw. (B) Drawing demonstrating the typical location of the cuneiform osteotomy at or just proximal to the level of the second tarsometatarsal joint. (C) Drawing demonstrating the location of the cuneiform osteotomy. Osteotomy is made perpendicular to the long access of the bone.
clinical review of the Cotton procedure, Hirose and Johnson reviewed a series of 16 patients who underwent correction of their residual forefoot varus with a plantarflexion medial cuneiform osteotomy. They utilized iliac crest autograft and internal fixation and found no incidence of nonunion or malunion. At the time of follow-up, all patients had mild to no pain with ambulation. Further, comparison of preoperative to postoperative weight-bearing radiographs showed an average improvement in Meary’s angle of $14^\circ$ ($-13^\circ$ preoperative, $1^\circ$ postoperative), demonstrating significant correction of forefoot varus.

In another recent clinical series, Lutz and Myerson reported on 101 medial cuneiform osteotomies performed in conjunction with a comprehensive flatfoot reconstructive procedure. This series did not report any nonunions, supporting the thought that the Cotton osteotomy heals predictably. Further, they demonstrated a statistically significant rate of improvement in Meary’s angle from a preoperative average value of $-23^\circ$ to an average postoperative value of $-1^\circ$.

Biomechanically, research has examined the weight-bearing characteristics of feet before and after Cotton osteotomy. Scott and colleagues used cadaveric specimens to evaluate plantar pressures and loading characteristics after a medial displacement calcaneal osteotomy, lateral column lengthening, and Cotton osteotomy. They found that the plantarflexion medial cuneiform osteotomy did increase average plantar pressure within the medial forefoot, but did not create off-loading of the lateral forefoot where the plantar pressures remained similar before and after the Cotton osteotomy. Benthien and associates found conflicting results in a similar cadaveric study by showing that the lateral forefoot pressure decreased with the addition of a medial cuneiform osteotomy.

There have been some complications found with the use of this procedure. In Hirose and Johnson’s series, 1 patient had a symptomatic screw that was removed, but there were no problems with nonunion or residual pain. In Lutz and Myerson’s larger series, there were 10 postoperative complications attributed at least in part to the Cotton osteotomy: 3 symptomatic screws, 2 bony exostosis, 1 sesamoid pain, 1 plantar fasciitis, 2 lateral column overload symptoms, and 1 recurrence of flatfoot deformity. Overall, the Cotton osteotomy has proven straightforward and useful in correcting residual forefoot varus in AAFD and should be carefully considered when

![Fig. 7. An osteotome is inserted into the cuneiform osteotomy and used to lever the first ray into plantarflexion, correcting forefoot varus. The first metatarsal head is corrected until it comes in line with the fifth metatarsal head in the coronal plane.](image-url)
there is no abnormality at the first TMT joint. Further, it allows for preservation of the first TMT joint and NC joint, permitting normal motion through the foot after reconstruction of Cotton’s “triangle of support.”

**TMT JOINT FUSION**

In 1934, Lapidus\textsuperscript{28} described a procedure for use in correction of hallux valgus where a distal soft-tissue procedure and medial eminence resection was performed along with arthrodesis of the first and second TMT joints. Since then, it has evolved to include arthrodesis of only the first TMT joint.\textsuperscript{29} Although its original intent was for use in correcting hallux valgus, surgeons have expanded the indications of the first TMT arthrodesis by using it to correct medial column deformity in AAFD.\textsuperscript{20}
Indications

Much like the Cotton osteotomy, the first TMT arthrodesis should be used as an adjunct to a comprehensive flatfoot reconstruction. It is used to correct residual forefoot varus in the AAFD when the deformity is identified to be primarily through the first TMT joint. As with the Cotton osteotomy, indications for this procedure are determined after careful preoperative physical examination and evaluation of preoperative weight-bearing radiographs. The first TMT arthrodesis should be employed when forefoot varus remains after correction of the hindfoot and there is clinical or radiographic evidence of significant joint arthrosis or instability. On physical examination, this is identified as gross instability or hypermobility of the first TMT joint or pain and crepitus with range of motion of the joint. Radiographically, abnormality of the first TMT joint is seen as asymmetric plantar gapping on weight-bearing lateral view, joint malalignment, or subluxation on weight-bearing lateral view (Fig. 10), or evidence of arthritic changes at the first TMT joint, such as joint space narrowing or sclerosis. With these findings, a joint-sparing procedure such as the Cotton osteotomy is no longer a predictable option because of the concern for residual joint instability or pain. As with the Cotton osteotomy, however, it is important to assess whether a first TMT fusion will correct the deformity sufficiently or whether a more proximal procedure such as a NC or TN fusion is necessary.

The first TMT fusion is typically performed as a last step in the reconstruction of the AAFD. After the hindfoot correction has been completed, the posture of the foot should be evaluated both clinically and radiographically. If significant forefoot varus deformity remains and there is gross instability, hypermobility, or degenerative change at the first TMT joint, then a first TMT fusion can be used to correct the deformity.

Fig. 9. (A) Preoperative lateral weight-bearing radiograph of a foot with AAFD. (B) Immediate postoperative C-arm image after surgical correction. The patient has undergone a medial displacement calcaneal osteotomy, a lateral column lengthening with interposition graft, a medial soft tissue reconstruction with flexor digitorum longus transfer to the navicular, and a Cotton osteotomy—fixed with a single, 0.062-inch K-wire. (C) Lateral weight-bearing radiograph after reconstruction has healed and patient is ambulatory.
Technique

The patient is positioned supine, with a bump under the ipsilateral buttock and a tourniquet around the thigh. The leg is prepped and draped in exactly the same manner as for the Cotton osteotomy. A dorsal incision is made over the level of the first TMT joint and the skin and subcutaneous tissues are carefully dissected until the EHL and EHB tendons are visualized and retracted medially and laterally, respectively. Care is taken to ensure the dorsalis pedis artery and deep peroneal nerve remain lateral to the surgical site, and, if they are visualized, they are retracted laterally with the EHB tendon. At this point, the first TMT joint is identified and a longitudinal incision is made through the joint capsule, which is then elevated medially and laterally to expose the joint. If there is any concern about identification of the first TMT joint, a C-arm fluoroscopy unit can be used for verification.

Once the joint is identified and exposed, the joint surfaces are prepared by removing all of the cartilage from the proximal aspect of the first metatarsal and the distal aspect of the medial cuneiform. This is completed with the use of instruments such as osteotomes, curettes, and rongeurs. It should be noted that the first TMT joint is quite deep from dorsal to plantar, measuring on the order of 3 cm. As such, care should be taken to prepare the full extent of the joint and avoid dorsiflexion through the arthrodesis, which would be created by incomplete preparation of the most plantar aspect of the joint. A lamina spreader or distraction apparatus using pins in the bone is helpful to gain access to the entire first TMT joint. Once all of the cartilage has been removed, the subchondral joint surface is further prepared by drilling or petaling the bone to increase the bleeding surface area for fusion.

After the surfaces are prepared, the first TMT joint must be reduced to the appropriate position of fusion. Clinical examination and C-arm fluoroscopy images are used to ensure that the medial column is being appropriately plantarflexed to correct the forefoot varus. As described for the Cotton osteotomy, this is accomplished by ensuring that the first metatarsal head rests in line with the fifth metatarsal head clinically and radiographically. If anatomic reduction of the first TMT joint does not correct the forefoot varus, resection of a small plantar wedge from the metatarsal base or the use of an interposition wedge graft much like a Cotton osteotomy may augment the correction. As with the plantarflexion cuneiform osteotomy, if a tricortical iliac crest autograft or allograft is used, the joint surfaces are flattened with a microsagittal saw and a wedge is cut to the size that creates the appropriate amount of plantarflexion through the first TMT fusion site. An osteotome is used to lever open the joint into an improved, plantarflexed posture and the graft is gently impacted into place. As an alternative to an opening wedge graft, one might consider a plantar

Fig. 10. Weight-bearing lateral radiograph demonstrating instability at the first TMT joint.
closing wedge osteotomy at the level of the first TMT joint. The authors have minimal experience with plantar closing wedge osteotomy of the cuneiform for the correction of forefoot varus and have been able to correct the majority of medial column deformities with a 5- to 8-mm dorsal bone wedge. However, for a more severe dorsiflexion deformity of the medial column with a normal first TMT and TN joint, we would favor either a double bone block opening wedge osteotomy as has been described for a dorsal bunion correction30 or a correction and stabilization through the naviculo-first cuneiform joint as similar to the Miller flatfoot procedure, the modified Hoke–Miller or the Durham plasty procedures.7,9,31

Fixation for the first TMT fusion is most commonly dual compression crossed screws or a single compression screw with a dorsal plate. The soft tissues and incision are then carefully closed and the patient is splinted. The postoperative protocol varies based on concomitant procedures that have been performed; however, typically the patient is casted and non–weight-bearing for 6 weeks from the time of their operation. At that point, they are typically transitioned to a boot for progressive weight bearing, assuming that the clinical and radiographic examinations do not raise concern for delayed healing. At 10 to 12 weeks after their surgery, the patient is usually transitioning from their boot to a shoe and progressing with activities as clinically tolerated (Fig. 11).

**Results**

In the past, there has been apprehension about performing the first TMT arthrodesis because of concerns for rates of nonunion. Some authors have cited rates as high as 12%; however, a recent paper by Thompson and colleagues32 had a better union rate. In their review of 182 patients who had undergone fusion of the first TMT joint for correction of hallux valgus or as a component to reconstruction of AAFD, the nonunion rate was only 4%. Of those, only half were symptomatic and required revision surgery. Further analysis shows that, of those patients who underwent first TMT fusion as part of a flatfoot reconstruction, there were no instances of nonunion. They attributed their low rate of nonunion to careful bone preparation, addition of bone graft, and the use of Achilles or gastrocnemius lengthening procedures as indicated to unload stresses through the forefoot.

Cadaveric biomechanical studies have investigated various constructs for Lapidus arthrodesis. One study showed no significant difference between locked plate fixation
and dual crossed lag screw fixation in terms of rigidity.\textsuperscript{33} Two studies, however, showed greater rigidity at first TMT fusion site with a locked plate as compared with dual crossed lag screws.\textsuperscript{34,35} DeVries and associates\textsuperscript{36} compared the clinical outcome of these fixation methods and found a significant increase in union rate when a locked plate was used as compared with the dual crossed screw technique. The dual screw technique did have an acceptable union rate of almost 90%, however, suggesting it to be a viable option. In our practice, we customarily use a lag screw and dorsal locked plate.

Although Thompson and colleagues\textsuperscript{32} showed a high rate of union that may not be attainable by all surgeons, at the least it suggests that the procedure is safe and reasonable. Outside of the cited nonunions, there were 6 superficial wound infections treated with oral antibiotics and 2 local wound breakdowns requiring wound care in addition to antibiotic treatment. No deep infections or incidence of more severe complications were identified. The procedure does sacrifice mobility of the first TMT joint; however, in the face of first TMT hypermobility or arthritic change at the first TMT joint, Lapidus fusion is a procedure that does quite well as an adjunct to a comprehensive flatfoot reconstruction.

**SUMMARY**

AAFD is a complex problem with a wide variety of treatment options. No single procedure or group of procedures can be applied to all patients with AAFD because of the variety of underlying etiology and grades of deformity. As the posture of the foot progresses into hindfoot valgus and forefoot abduction through attenuation of the medial structures of the foot, the medial column begins to change shape. The first ray elevates and the joints of the medial column may begin to collapse. Careful physical examination and review of weight-bearing radiographs determines which patients have an associated forefoot varus deformity that may require correction at the time of flatfoot reconstruction.

Correction of an AAFD requires a combination of soft-tissue procedures to restore dynamic inversion power and bony procedures to correct the hindfoot and midfoot malalignments. If after these corrections forefoot varus deformity remains, the surgeon should consider use of a medial column procedure to recreate the “triangle of support” of the foot that Cotton described.\textsuperscript{5} If the elevation of the medial column is identified to be at the first NC or the first TMT joint, then the joint should be carefully examined for evidence of instability, hypermobility, or arthritic change. If none of these problems exist, then the surgeon can consider use of the joint-sparing Cotton medial cuneiform osteotomy to correct residual forefoot varus. However, if instability, hypermobility, or arthritic change is present, then the surgeon should consider use of an arthrodesis of the involved joint to correct residual forefoot varus. Either procedure provides a safe and predictable correction to the medial column as part of a comprehensive surgical correction of AAFD.

**REFERENCES**