The Cotton Osteotomy: A Technical Guide

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The authors in this study hope to offer a summation of the classic and recent literature while offering a detailed illustrated technique guide for the medial cuneiform, or "Cotton osteotomy." Usually performed as an ancillary procedure, the Cotton osteotomy offers the surgeon an additional option for correction of various distal medial column deformities while preserving midfoot articular surfaces. (The Journal of Foot & Ankle Surgery 48(4):506–512, 2009)

Key Words: allogeneic bone graft, forefoot varus, medial cuneiform, pes planovalgus, tarsal

A medial cuneiform plantarflexory opening wedge osteotomy, or Cotton osteotomy, is a powerful surgical adjunctive procedure in the treatment of collapsing pes planovalgus with persistent rigid forefoot varus deformity (1). It is useful primarily for plantarflexion of the medial column (2). Additionally, it has been used for the correction of tarsal coalitions, overcorrected clubfoot, elevatus deformity, forefoot supinatus, and hallux limitus (3–5). As stated by several authors, the cuneiform osteotomy is a reliable, predictable, and relatively simple procedure, with few associated complications (1, 3, 6). Although attempts have been made in both the cadaveric model and the human foot, the literature is sparse regarding the biomechanical effect of the Cotton osteotomy (7–9). The authors in this study hope to offer a summation of the classic and recent literature while offering a detailed illustrated technique guide for the Cotton osteotomy.

Classical Literature Review

Riedl in 1908 is often credited with the first medial cuneiform osteotomy to repair hallux abductovalgus, and he proposed using a closing wedge osteotomy for correction of the cuneiform's atavistic deformity (10, 11). Two years later, Young was reported to have used an opening wedge cuneiform osteotomy for the correction of hallux abductovalgus (12). In February of 1936, Frederic J. Cotton published ''Foot Statics and Surgery'' in *The New England Journal of Medicine* (1), although he had previously presented his ideas at the annual meeting of the New England Surgical Society on September 28, 1935. Specifically, Cotton described an ''operation of the first member, the cuneiform wedge'' and believed that the procedure could be used in pedal deformities where the first metatarsal head ''cannot be made to carry any weight.'' Additionally, he believed that use of this procedure for the treatment of flatfoot would be more beneficial if it was reinforced with muscular training and exercise (1). Cotton wrote: ''The operation is simple, not painful, and weight bearing begins within a month. In the short series of cases done since I devised this operation, there has been no trouble in any and the correction obtained has in no case been lost.'' In his article, Cotton further noted other deforming forces, such as a short heel cord, that could influence pes valgus as well as hallux valgus. Interestingly, it was the ''ascent'' of the first metatarsal associated with hallux valgus deformity that served as Cotton's initial indication for the cuneiform osteotomy. Furthermore, he used the resected medial eminence as an autologous graft (Fig 1) and suggested that the resected bone was a ''good wedge'' for the first cuneiform (1).

Hirose and Johnson (13) provided the first peer-reviewed report of the Cotton osteotomy. They described a series of 15 cases comprised of pediatric and adult patients, and undertook adjunct hindfoot osseous and soft tissue procedures along with the medial cuneiform osteotomy. Furthermore, they purported that the procedure was more superior to first tarsometatarsal arthrodesis because of preservation of first

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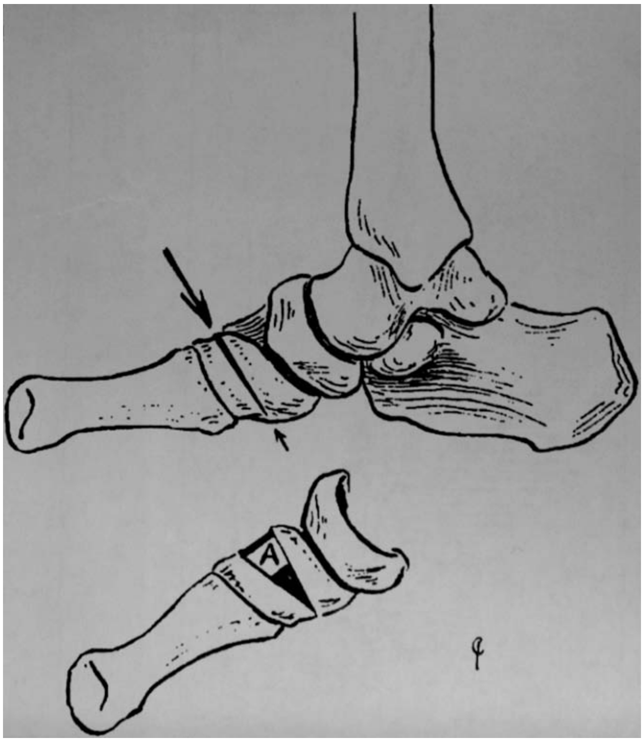

FIGURE 1 Reprint of original illustration of Frederic J. Cotton's osteotomy. (Reprinted with permission from Cotton FJ. Foot statics and surgery. N Engl J Med 214:353–362, 1936. Copyright. All rights reserved.)

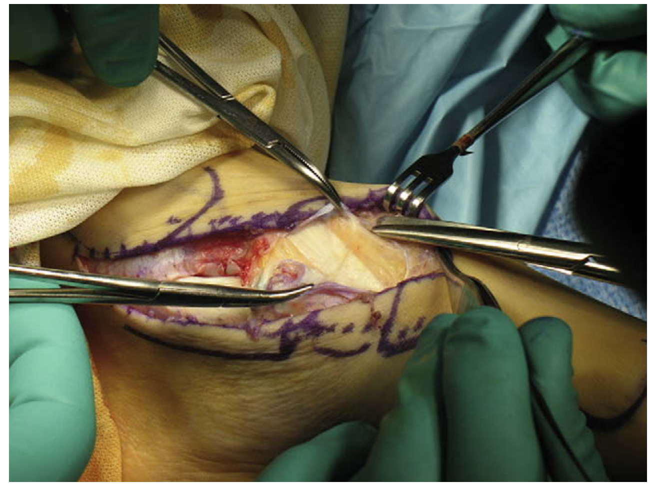

FIGURE 2 Care is taken to preserve the tendon sheath of the tibialis anterior. The medial cuneiform window is found between the tibialis anterior and extensor hallucis longus tendons.

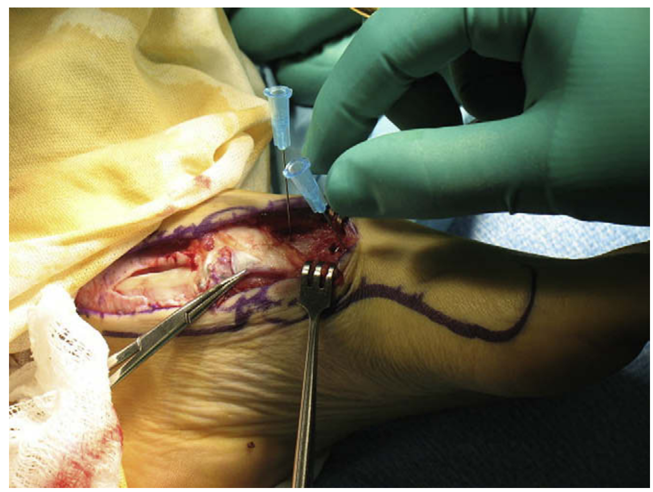

FIGURE 3 Twenty-five-gauge needles are used to assist in demarcating both the proximal and distal medial cuneiform margins for centralization of the osteotomy.

ray mobility and a more predictable outcome with the ability to easily adjust the amount of correction. They felt that the need for a structural bone graft was a disadvantage of the Cotton osteotomy. Still further, they recommended use of the medial cuneiform osteotomy for the treatment of residual fixed varus after hindfoot surgical correction, although they could not conclude that the procedure contributed to hindfoot correction because of the combined procedures and found it difficult to preoperatively plan for the procedure.

As an ancillary procedure for the flexible flatfoot in stage IIB posterior tibial tendon dysfunction, the Cotton osteotomy is a useful procedure in addition to a posterior calcaneal displacement osteotomy or an Evans calcaneal osteotomy (2). Soft tissue repair and/or soft tissue lengthening procedures have also been described as useful adjuncts to the Cotton osteotomy (2, 14). Finally, Jacobs and Oloff (3) investigated medial column procedures and performed the Cotton procedure in 8 patients with an average age of 18.4 years, and showed excellent result in 7 (87.5%) patients.

Technique Guide

The patient is typically placed in a supine position with a bump placed under the ipsilateral hip to effect internal rotation of the operative extremity. Initial incision planning is dependent on concomitant procedures of the medial column. Primary dissection of the medial cuneiform includes a 3- to 4-cm incision strategically placed medial to the extensor hallucis longus tendon. The tibialis anterior tendon is used intraoperatively as an anatomical reference point. Blunt dissection is carried down through subcutaneous tissue with care taken to avoid and protect the neurovascular structures. Branches of the saphenous venous network are typically encountered, as well as branches of the medial dorsal cutaneous nerve and saphenous nerve. The tibialis anterior tendon should be mobilized and retracted plantarly with its insertion protected throughout the procedure (Fig 2). At this point, the first metatarsocuneiform joint distally, and the navicular-medial cuneiform joint proximally, should

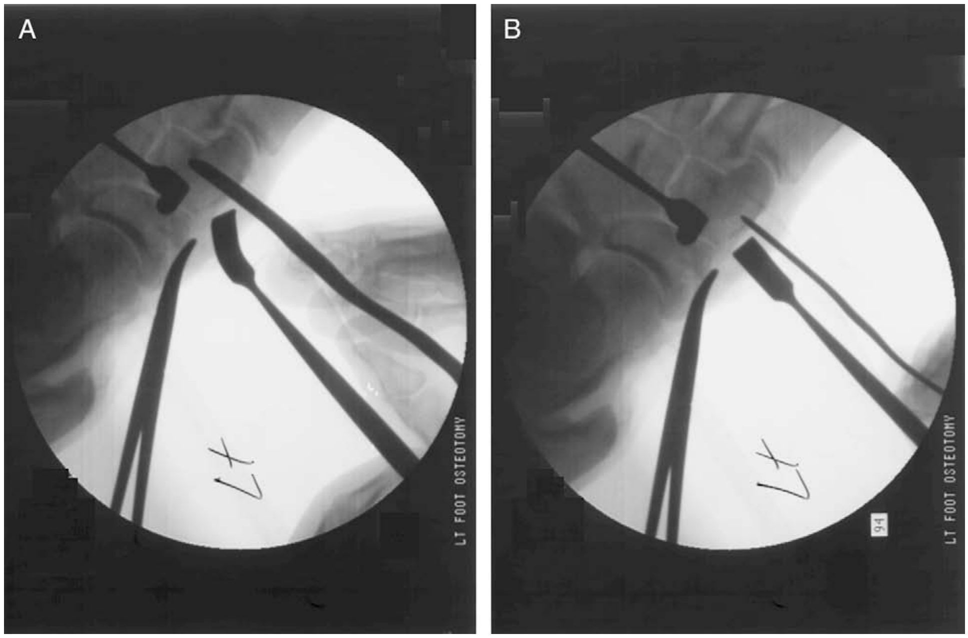

FIGURE 4 (**A**) Before performing the osteotomy, the use of intraoperative C-arm improves and confirms central positioning as well as maintains an extra-articular osteotomy. (**B**) Placement usually falls 2-3 mm proximal to the second tarsometatarsal joint, as seen on the dorsal plantar C-arm view.

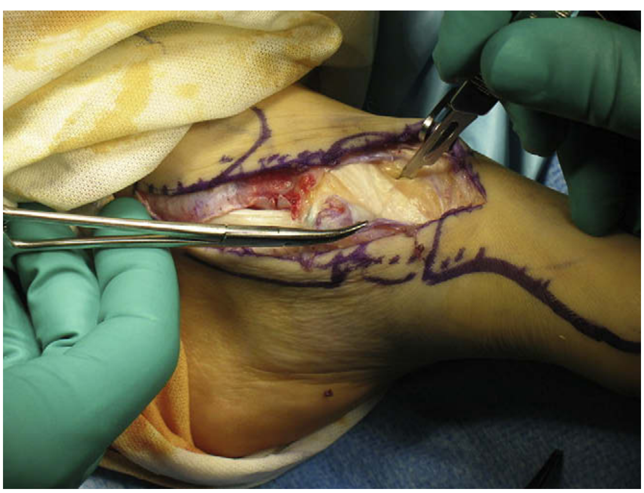

FIGURE 5 A deep fascial incision and periosteal incision are performed at the Cotton osteotomy site.

FIGURE 6 A Freer elevator or small key elevator is chosen for periosteal dissection and minimal periosteal disruption is preferred. The goal is to limit dorsal and plantar cuneiform ligamentous disruption.

be identified. Intraoperative fluoroscopy with the use of small-gauge needles (Fig 3) can be used to assist in identification of the joints. Some authors describe using the second metatarsocuneiform joint as a marker for placement of the medial cuneiform osteotomy, wherein an imaginary line can be drawn from the second metatarsocuneiform joint toward the medial cuneiform (4, 13). Using the second metatarsocuneiform joint as an anatomical landmark, we have found the optimal location of the osteotomy to typical lie 2-4 mm proximal to this reference point (Fig 4). The surgeon should use caution to preserve the dorsal tarsal ligaments proximal and distal to the planned, to maintain stability of the adjacent joints.

After determining the location of the planned osteotomy, a small dorsal, longitudinal periosteal incision is made, and a periosteal elevator is used to expose the cortex of the medial cuneiform in preparation for osteotomy (Figs 5 and 6). The

FIGURE 7 A microsagittal saw is used for the osteotomy. Care is taken to prevent iatrogenic disruption of the intermediate cuneiform. Also, the osteotomy is positioned accordingly. In this patient, a true sagittal plane osteotomy is desired; alterations in frontal plane alignment drastically alter the forefoot position.

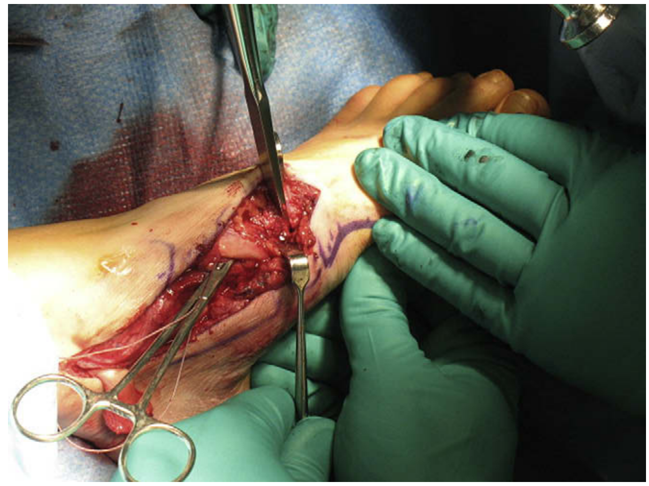

FIGURE 8 An osteotome is inserted within the osteotomy site to initiate mobilization for graft placement.

osteotomy is then made with the use of a sagittal saw, although osteotomes can also be used at the discretion of the surgeon (Fig 7). Particular attention should be made to avoid violation of the plantar cortex of the medial cuneiform, and also to prevent iatrogenic engagement of the intermediate cuneiform. After completion of the bone cut, mobilization of the osteotomy can be achieved with the use of 2 small osteotomes, a single large osteotome (Fig 8), or with the careful use of a smooth lamina spreader. The intraoperative benefits of osteotomy mobilization are 2-fold: 1) ligament mobilization allows assessment of the amount of reduction needed to achieve adequate correction, and 2) the size of the required bone graft can be measured. Once the amount of cuneiform displacement and graft size are determined, placement of the subtalar joint in the neutral position as well as loading of the forefoot to simulate weightbearing are undertaken in an effort to assess the degree of deformity correction. These maneuvers can be undertaken with or without fluoroscopic guidance.

A number of options are available for the choice of autogenous bone graft to be used in the dorsally based, medial cuneiform osteotomy, including iliac crest, calcaneus, tibia, and even Cotton's own preference, the resected medial eminence of the first metatarsal head (1, 13). Other common choices include freeze-dried tricortical iliac crest or femoral head allografts. Low-profile small bone opening wedge plates (Arthrex Low Profile Plate and Screw System; Arthrex, Inc., Naples, FL) have also been successfully used for the Cotton osteotomy (8). It has been the author's training and experience that freeze-dried, corticocancellous allogeneic graft yields satisfactory results in this location, while simultaneously preventing donor site morbidity, and other authors have made this same observation in regard to the use of this type of bone graft in the tarsus (15). Although the precise size and shape of the bone graft will vary in accordance with the requirements of the individual patient, the benefits of a dorsal cortical base are that it helps to prevent graft extrusion and collapse. A trapezoidal graft shape can also be used, typically measuring approximately 8 mm in the pediatric patient, and 4-6 mm in the adult (Fig 9). The use of a Weinraub Joint Spreader (Innomed, Inc., Savannah, GA) facilitates the insertion of the dorsally based graft (Fig 10).

The Cotton osteotomy is rarely fixated because of the intrinsic stability of the dorsal and plantar ligaments, and the broad insertion of the tibialis anterior. If required, either a Kirschner wire or a small fixation plate can be used to stabilize the osteotomy and bone graft. Although Cotton began ambulation within just 1 month, it has been our experience that this osteotomy is typically used concomitantly with adjunctive procedures that necessitate longer periods of immobilization. Intraoperative C-arm image intensification fluoroscopy and postoperative radiography are used to further confirm graft placement and forefoot realignment (Fig 11). Radiographic consolidation at the operative site usually appears within 6 to 8 weeks after the operation, although it may take longer in some adults.

Discussion

The authors have had success with the Cotton osteotomy to surgically correct flexible flatfoot deformities, and have often combined the procedure with the Evans calcaneal osteotomy with or without medial tendon repair and a gastrocnemius recession. The precise effect of the Cotton osteotomy on the medial and lateral columns, and the degree of hindfoot

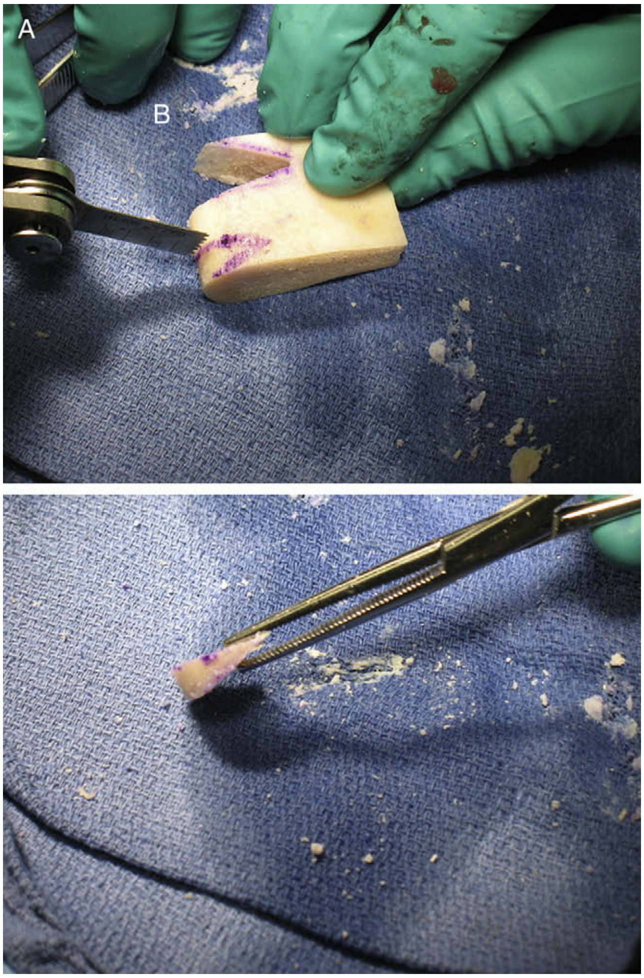

FIGURE 9 (**A**) Graft preparation from a tricortical allogeneic iliac crest. (**B**) The larger harvested graft is used for the Evans osteotomy, also performed during this case.

FIGURE 10 A Weinraub Joint Spreader (Innomed, Inc., Savannah, GA) is used for joint mobility while improving graft insertion.

correction, remains unknown. According to Lee et al (2), in a review of the corrective ability of flatfoot procedures, on a relative scale of 0 to 4, the Cotton osteotomy scored 3 in regard to its ability to correct medial column sag, whereas it scored 1 in regard to its ability to correct rearfoot eversion and peritalar subluxation. A key benefit of the Cotton osteotomy, or any periarticular osteotomy for that matter, is preservation of adjacent joint function. Other studies have examined the effect of forefoot-driven rearfoot changes after medial cuneiform osteotomies, used for the treatment of metatarsus adductus and varus foot deformities, including Viehweger et al (9), who looked at 18 patients (31 feet) and attributed hindfoot translation to an induced rotary force at the talonavicular joint. They postulated that when the proximal portion of the medial cuneiform migrates proximally, the strong dorsal ligament imparts a retrograde supinatory effect on rearfoot motion. So, although joint preservation is a feature of the Cotton osteotomy, dynamic changes at adjacent joints likely occur and further research is needed to quantify this motion.

Scott et al (7) analyzed plantar pressures after postsurgical procedures, including the Cotton osteotomy, for stage II posterior tibial tendon insufficiency in a cadaver model, and showed that the osteotomy was successful in redistributing load to the medial column after lengthening of the lateral column. Although medial redistribution of load was identified by Scott et al (7), they did not observe significant reduction in lateral forefoot loading after the Cotton osteotomy. As a result of their investigation, they suggested that further scientific analysis of different combinations of osseous and soft tissue procedures would be needed to more effectively explain load distributions, thereby enabling surgeons to establish a more definitive operative plan and to select an appropriately sized bone graft.

League et al (8) studied radiographic and pedobarographic comparison of various techniques for medial cuneiform osteotomies in a cadaver model, and showed a significant difference between the pre-osteotomy and post-osteotomy percentage of plantar pressure borne medially and laterally. In their study, moreover, opening medial cuneiform osteotomies with femoral head allograft or a block plate were both effective at increasing medial column pressures in a deficient foot while reducing lateral column pressures.

Surgical Pearls Related to the Cotton Osteotomy

1) Upon dissection dorsomedially, take care to avoid injuring the tibialis anterior tendon. Mobilization and retraction of the tendinous insertion plantarly will allow direct visualization of the medial cuneiform.
2) Care should be taken to limit extensive dissection of both the dorsal and plantar metatarsocuneiform and

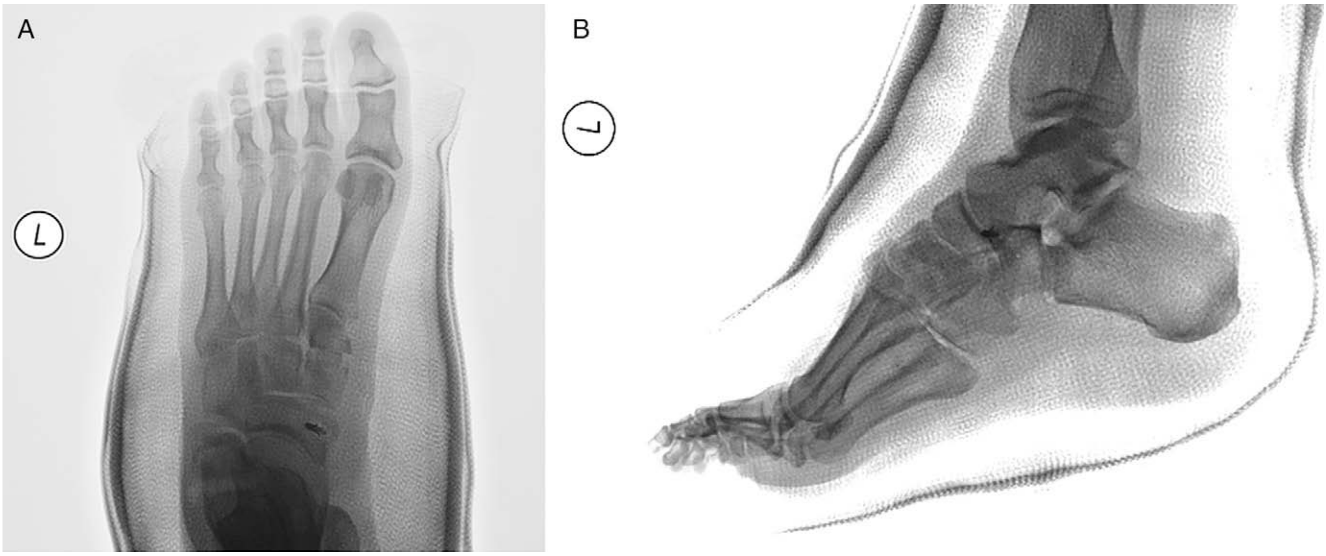

FIGURE 11 (**A**) Postoperative radiographs showing the centrally placed Cotton osteotomy and graft placement. (**B**) An Evans calcaneal osteotomy, flexor digitorum longus tendon transfer, and a tibialis posterior advancement were concomitantly performed.

naviculocuneiform ligaments. This will prevent migration of the proximal and distal segments of the cuneiform after the osteotomy is made and will maximize the effect of the graft.

3) Recognize and locate the joints proximal and distal to the medial cuneiform. The tibialis anterior will help delineate these anatomical margins. The use of intraoperative fluoroscopy with small-gauge injection needles may assist the surgeon in joint identification.
4) The use of either 2 small osteotomes or a smooth lamina spreader will allow fluoroscopic assessment of the desired correction before graft placement and will facilitate measurement of the required amount of graft. The authors often use up to an 8-mm graft in the pediatric population, whereas graft sizes usually range from 4-6 mm in the adult patient.
5) Graft preparation should include a cortical dorsally based graft surface to provide strength against compressive forces while limiting both dorsal prominence and collapse.
6) Optimal graft size, shape, and position will vary with the desired correction. Depending on the planal dominance of deformity, an overzealous transverse plane correction may create a metatarsus adductus deformity.
7) As suggested by Boberg and McMurray (16), the use of this procedure in a severely hypermobile foot may increase faulting at the naviculocuneiform and/or talonavicular joints, so it is best to evaluate proximal joint function before procedure selection.

In conclusion, 73 years after Cotton first described his ‘‘operation of the first member’’ (1), surgeons have adapted the technique and continue to perform a variety of cuneiform opening wedge osteotomies. Modifications, such as concomitant lateral column lengthening, calcaneal osteotomy, and equinus release, have enabled foot and ankle surgeons to more effectively treat a wide range of common pedal deformities associated with pes valgus. In fact, it is interesting to note that recently the surgical term ‘‘all-American operation’’ has been used to describe a specific combination of procedures for the treatment of stage II posterior tibial tendon insufficiency (17, 18). The component elements of the ‘‘all-American operation’’ include posterior tibial tendon debridement, Achilles tendon lengthening, lateral column lengthening, medializing calcaneal osteotomy, and flexor digitorum longus transfer. In combination, these procedures make for a powerful surgical option for repair of the collapsing pes valgus deformity. In an analogous surgical scenario, as pertains to the patient whose photographic images were used to illustrate this report, the Cotton osteotomy and bone graft were used in conjunction with an Evans calcaneal osteotomy, a flexor digitorum longus tendon transfer, and triceps surae equinus release for repair of a complex pes valgus deformity in an adult.

Although difficult to assess, it is important that we continue our efforts to understand the impact of the surgical elements combined for repair of the pathological flatfoot, from a biomechanical standpoint and in regard to long-term clinical follow-up. The Cotton osteotomy, as described in this technical report, provides the surgeon with a powerful method for addressing the medial column. Despite its apparent clinical usefulness, randomized controlled trials and prospective cohort studies are needed to further elucidate the efficacy of this procedure in comparison with other interventions, and to formulate a more precise understanding of its individual influence on hindfoot motion.

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