REFINEMENTS IN THE EVANS CALCANEAL OSTEOTOMY

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INTRODUCTION

The Evans calcaneal osteotomy, along with its companion procedures (medial arch tenosuspension, triceps surae equinus correction), has proven to be a very effective surgical technique for the correction of a flexible pes valgus deformity.

In 1961, Evans recognized that the lateral column of the foot was longer than the medial column in talipes equinovarus, and in calcaneovalgus, the lateral column was shorter.[1] Following the over-correction of a clubfoot deformity with a shortening calcaneocuboid fusion, which caused a collapsed flatfoot, Evans postulated that lengthening the lateral column on a flexible flatfoot would rebalance the midtarsal joint and correct the deformity.[2] The osteotomy was performed by inserting a bone graft into the anterior beak of the calcaneus. The procedure was introduced in 1975. Surgeons from the Podiatry Institute have successfully performed this procedure, along with ancillary procedures, since 1979.

INDICATIONS

The Evans osteotomy addresses the predominant transverse plane compensation in a foot with a high subtalar joint axis. This pathologic foot type can become quite painful and less propulsive than a normal foot. It demonstrates a marked amount of midtarsal pronation with obvious medial talar bulging. Radiographically, the foot demonstrates an increased cuboid abduction angle, as well as a subluxated talonavicular joint on the DP radiograph.

The Evans osteotomy, in conjunction with properly utilized adjunctive procedures, adducts and relocates the forefoot on the rearfoot at the midtarsal joint. This is demonstrated by a decrease in the calcaneocuboid angle, and reduction of the talonavicular joint. The synergistic effect of these combined procedures acts to realign the midtarsal joint, plantarflex the first ray, stabilize the naviculocuneiform joint, and reduce rearfoot pronation. Postoperative radiographs reveal a decreased talocalcaneal angle (both DP and lateral radiographs), an increase in the calcaneal inclination angle, and an increase in the first metatarsal declination angle.

Lengthening of the lateral column in pediatric patients between the age of 5 to 9 years allows the peroneus longus tendon to plantarflex the first ray. This is accomplished in patients with a mild to moderate degree of forefoot supinatus, which resolves due to the improved mechanical advantage of the peroneus longus.

In the preoperative analysis of these patients, one must identify a pre-existing metatarsus adductus deformity, which often presents as a compensated "Z"-foot. Overcorrection of a flatfoot deformity can potentially lead to an increase in the degree of metatarsus adductus.

An in-depth, comprehensive treatise and postoperative study of the Evans procedure was prepared by Mahan and McGlamry in 1987.[3] The technique of the Evans osteotomy will be clinically illustrated, with elaboration on some of the recent developments.

SURGICAL TECHNIQUE

Incision

The topographical anatomy of the lateral aspect of the rearfoot is palpated and identified with a skin marker prior to making the skin incision. By adducting the midfoot at the calcaneocuboid joint, the outline of the anterior beak of the calcaneus can be identified and diagrammed. If any uncertainty remains, the calcaneocuboid joint can be identified with a small gauge needle. After the incision has been planned, the limb is exsanguinated and a thigh tourniquet inflated to an appropriate pressure.

The skin incision should follow the oblique relaxed skin tension lines on the lateral aspect of the calcaneal beak so that the central aspect of the oblique incision crosses the desired line of the osteotomy. This osteotomy line is located between 1.0 and 1.5 cm proximal to the calcaneocuboid joint, depending on the size of the calcaneus.

A 3 to 4 cm incision is made from distal medial to the sinus tarsi, extending proximal-lateral over the lateral aspect of the calcaneus. The intermediate dorsal cutaneous nerve is often identified dorsally, and the sural nerve may be encountered plantar-laterally. Both nerves should be carefully retracted with vessel loops. Care should be taken to avoid the peroneal tendons, which will be immediately encountered on the plantar lateral aspect of the calcaneus. Placing the incision within the relaxed skin tension lines will result in a less-conspicuous, fine-line scar.

Dissection

Dissection is carried through the superficial fascia which overlies the extensor digitorum brevis muscle belly. A natural cleavage plane is developed between the superficial and deep fascia to allow gentle retraction of the skin and subcutaneous tissues, prior to incising the deep fascia.

The deep fascia is incised parallel to, and just dorsal (3 to 4 mm) to, the peroneal tendons. This incision allows repair of the deep fascia, and maintains the intact peroneal tendon sheath. With the deep fascia retracted, the EDB can be gently dissected and lifted from the dorsolateral aspect of the calcaneus. Often, a plexus of veins is encountered beneath the EDB. The insertion of the EDB remains intact at the posterior sinus tarsi. Care is taken to avoid the fibrous calcaneocuboid ligament. Preservation of this ligament is important to prevent dorsal migration of the anterior beak of the calcaneus. A Freer elevator is then used both dorsally and plantarly to the calcaneus to allow the long end of a Senn retractor to protect the soft tissues and peroneal tendons.

A periosteal incision is made vertically over the lateral aspect of the calcaneus at the desired osteotomy line. The periosteal margins are reflected slightly to expose the lateral calcaneus, while the calcaneocuboid ligaments are preserved.

Osteotomy

The specific distance of the osteotomy from the calcaneocuboid joint should be anticipated preoperatively. In a younger, immature calcaneus, the distance will be closer to 1 cm, whereas in an older, more mature calcaneus, the distance approaches 1.5 cm. This variability allows the surgeon to osteotomize the anterior calcaneus, while avoiding both the middle and anterior subtalar facets. It is also advised to not osteotomize the calcaneus less than 1 cm from the calcaneocuboid joint, in order to avoid potential complications such as avascular necrosis or osseous nonunion. However, a distance of 4 mm was recommended by Anderson and Fowler,[4] who reported no complications in five patients and nine procedures.

A Zimmer #38 blade on a sagittal saw can be used in most cases to perform the osteotomy. If a longer blade is necessary (#40), the #38 blade can still be used to score the osteotomy line, due to the inherent stability of the shorter blade.

The osteotomy is made in a through and through fashion, from lateral to medial. This allows maximal lengthening of the lateral column with a trapezoid-shaped or truncated bone graft. An earlier technique which maintained a medial hinge and used a triangulated graft was slightly more stable, however, it did not allow for as much lengthening. Following the osteotomy, a 10 to 14 mm osteotome is used to manipulate the osteotomy and stretch the long plantar ligament. This allows the recipient site to accept the bone graft.

Bone Graft

Freeze-dried (lyophilized) allogeneic bone graft material is an excellent source of bone for the Evans osteotomy. The bone incorporates quickly into the well-vascularized calcaneus and obviates the need for harvesting autogenous bone from the patient's tibia or iliac crest. A properly-sized portion of tricortical iliac crest can be remodeled for the specific size indicated. This graft provides stability through its cortical shell. The cancellous core provides a scaffold for osteoconduction, and also allows for early revascularization.

At the beginning of the surgery, the graft should be rehydrated in sterile saline. Adequate stabilization of the graft, at the time of graft modeling, can be accomplished through the use of towel clamps or Kocher clamps. Irrigation is supplied to the graft during the high-speed power tooling to prevent thermal damage to the bone.

A slight angle on the graft, from lateral to medial, allows for easier placement of the graft and facilitates maximal correction. The shape is actually trapezoidal when viewed from above, and horseshoe-shaped when viewed from the side. The width of the lateral aspect of the graft ranges from 4 to 8 mm, depending on the patient. The medial aspect is slightly more narrow (approximately 1 to 2 mm) than the lateral edge for ease of insertion. The length must closely approximate the actual width of the calcaneus (approximately 1.5 to 2.0 cm) at the level of the osteotomy.

A wide piece of iliac crest which approximates the height of the anterior calcaneus should be used. Two J-shaped pieces of graft may be necessary to obtain this amount of height if the bone bank specimens are not of sufficient size. Both the graft and the adjacent calcaneal surfaces may be fenestrated to aid in revascularization of the graft. A power wire driver with a 0.045" Kirschner wire can be used for this task. A Podiatry Institute Bone Impactor® (K-Medic Inc., Leonia, NJ) is used to impact the graft into the osteotomy, without fracturing the cortex of the graft. This instrument has a polyethylene cap which is less traumatic than a metallic impactor.

Care must be taken to not dorsally dislocate the capital fragment or anterior calcaneus. In the event of unstable graft placement, Kirschner wire fixation is effective in maintaining osseous stability. The wire enters the distal calcaneal fragment just proximal to the calcaneocuboid joint, traverses the bone graft, and is seated proximal to the osteotomy in the calcaneus. The K-wire can be left percutaneous or buried. Intraoperative radiographs can be used to confirm the placement of the graft, position of the calcaneocuboid joint, or relocation of the talonavicular joint.

Insertion of a graft does not permit periosteal closure. The subsequent layers are sutured using standard wound closure. Occasionally, a temporary closed suction drain may be employed if excessive bleeding is anticipated.

Graft Healing

An intricate sequence of histological as well as immunological events are necessary for successful incorporation of the bone graft. This incorporation requires cooperative interactions between both the graft and the recipient host site. The process of graft incorporation begins with hematoma formation, followed by a local inflammatory response, and finally revascularization and osseous remodeling. The remodeling phase is characterized by activation, resorption, and new bone formation.[5] Stevenson and Horowitz suggest that the fate of the graft in a healthy bed is determined during the first four weeks after the graft has been placed in the host.[6] Ultimately, the fate of the graft may be sealed at the time of the surgery as technique will often dictate the success of the ensuing cascade of events responsible for incorporation.

Successful incorporation of a bone graft may be defined as concurrent revascularization and substitution with host bone, without substantial loss of strength. Radiographic signs of consolidation include the loss of cortical margins at the graft host interface, and observation of the trabecular pattern crossing the graft area.

CLINICALLY ILLUSTRATED TECHNIQUE

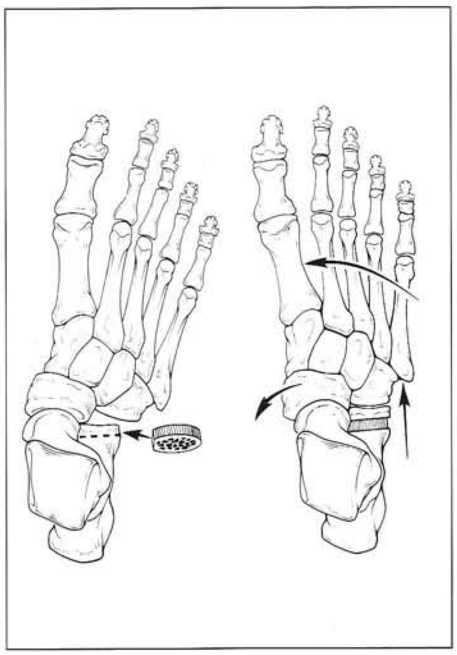

Figure 1. The effect of lateral column lengthening, utilizing the Evans osteotomy with insertion of a bone graft.

Figure 2. Posterior view of postoperative foot (right) following flat-foot reconstruction. Note the transverse plane abduction of the left preoperative foot, demonstrating the "too many toes sign".

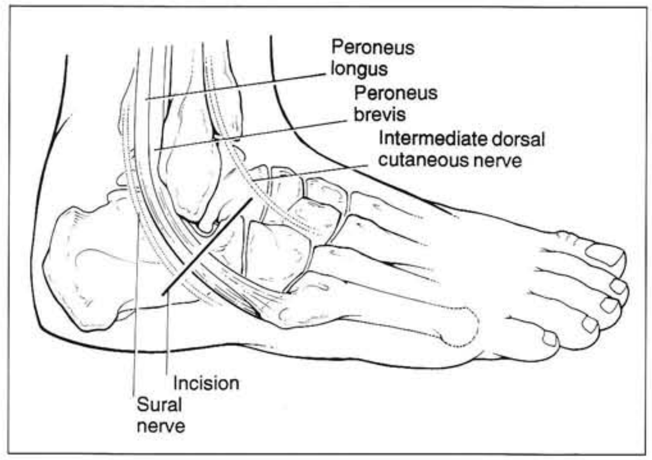

Figure 3. Demonstration of the topographical landmarks used to plan the incision placement, which is oblique in orientation.

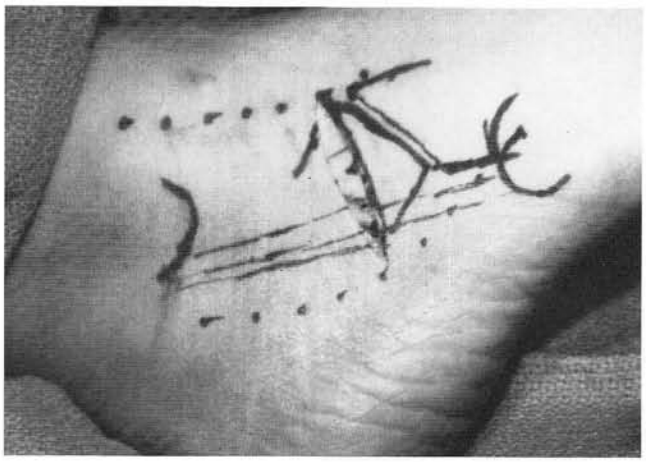

Figure 4. Typical skin incision.

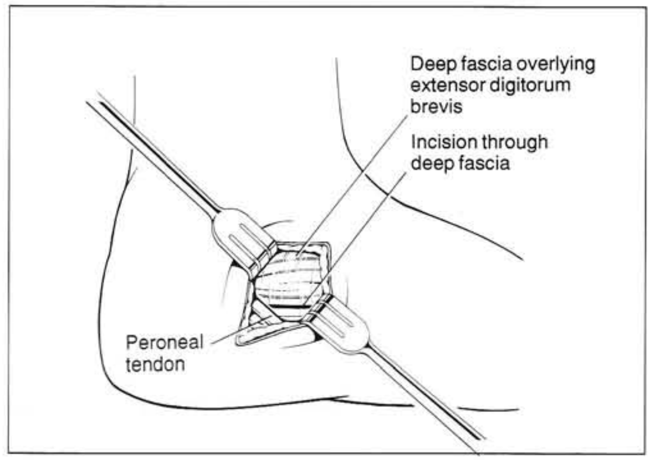

Figure 5. Demonstration of the deep fascial incision, which is superior and parallel to the peroneal tendons.

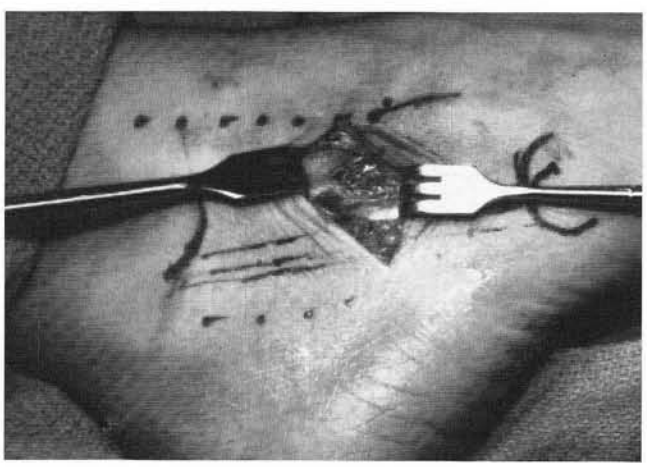

Figure 6. Incision through the deep fascia.

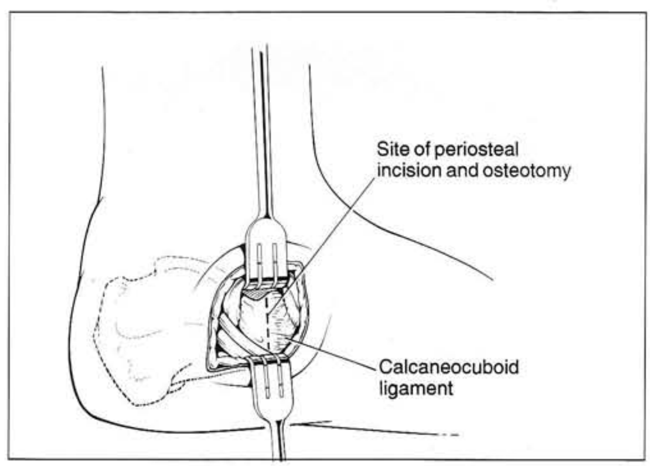

Figure 7. Orientation of the periosteal incision. Both the periosteal incision and the osteotomy are made in a vertical fashion, between the anterior and middle subtalar joint facets.

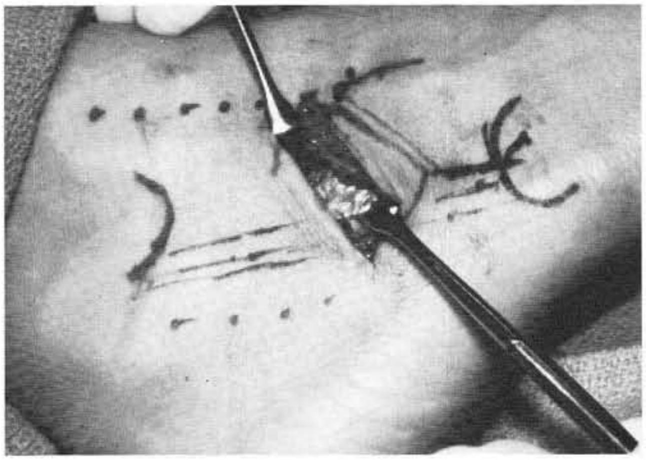

Figure 8. Site of the periosteal incision and calcaneal osteotomy.

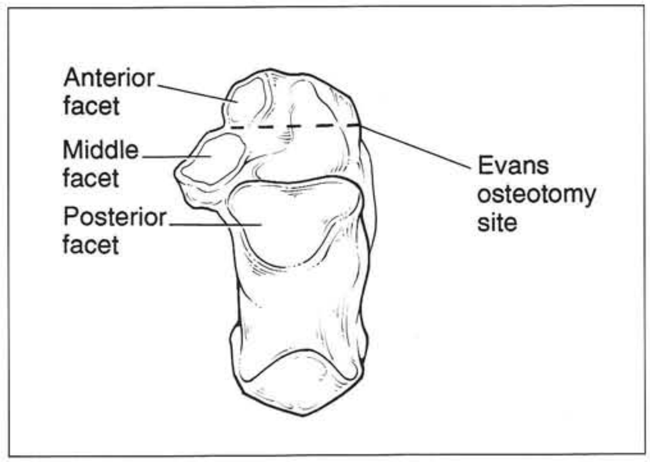

Figure 9. The dorsal aspect of the calcaneus demonstrating the osteotomy site, which is between the anterior and middle facets of the subtalar joint.

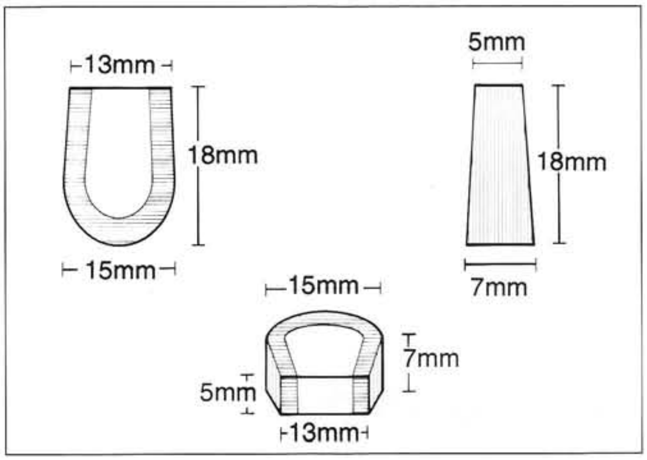

Figure 10. Three views of the prepared tricortical iliac crest bone graft.

Figure 11. Preoperative DP radiograph. Note the subluxation of the talonavicular joint and the increased cuboid abduction angle.

Figure 12. Postoperative DP radiograph, demonstrating reduction of the talonavicular joint and realignment of the lateral column.

Figure 13. Preoperative lateral radiograph, demonstrating excessive pronation of the tarsus and instability of the medial column.

Figure 14. Postoperative lateral radiograph, demonstrating an increased calcaneal inclination, decreased talar declination, and correction of naviculo-cuneiform fault.

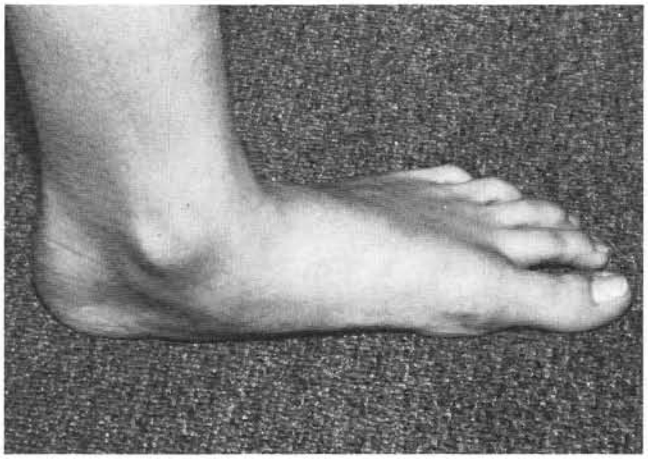

Figure 15. Preoperative appearance of the collapsed medial longitudinal arch.

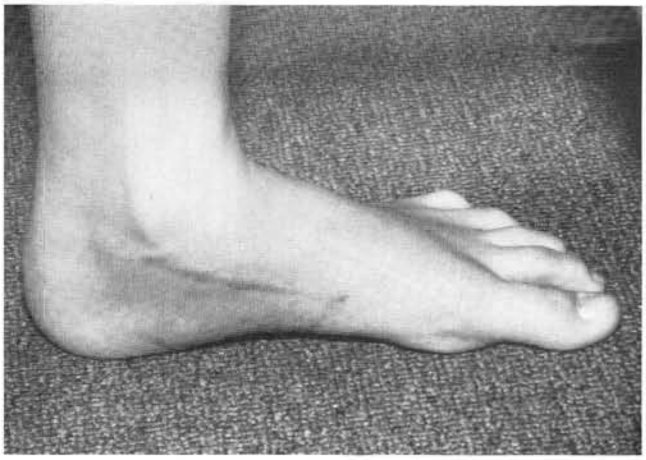

Figure 16. Postoperative appearance demonstrates near normal appearance of the medial arch.

COMPLICATIONS

In addition to the obvious surgical complications such as overcorrection, under-correction, wound dehiscence, and infection, the inherent risks associated with a bone graft must be considered. In over 600 cases performed by members of the Podiatry Institute, three cases of delayed union have been identified and successfully treated with electric stimulation. One case of non-union was treated with revisional surgery, utilizing autogenous iliac bone for re-grafting. Another potential complication is the exacerbation of a preexisting metatarsus adductus deformity, as lateral column lengthening can result in excessive forefoot adduction.

Reconstructive surgery in the developing pediatric or adolescent patient possesses certain inherent risks. Since these patients have not attained full growth, they should be followed for an appropriate, extended postoperative course. The surgeon should be aware of the tremendous responsibility regarding pediatric patients. The statute of limitations for these patients is often until 18 years of age.

POSTOPERATIVE CARE

Strict non-weight bearing in a cast for 10 to 12 weeks is imperative for a successful surgical result. Evidence of graft consolidation is identified through the use of serial radiographs at regular intervals (every 4 to 6 weeks). Similarly, radiographic evaluation is performed when a change in postoperative management is anticipated. Three views are used to evaluate the parameters of correction and osseous healing. The lateral oblique projection affords an excellent view of the healing graft site.

Following casting, physical therapy is directed at strengthening the atrophic limb, improving flexibility, and increasing the range of motion of the rearfoot complex. A neutral position orthotic device will help support the corrected position of the reconstructed foot. A neoprene anklet can be used during the initial post-casting period to provide compression and decrease edema.

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