Incidence of Nonunion and Maintenance of Correction of the Unfixated Evans Calcaneal Osteotomy and Cotton Medial Cuneiform Osteotomy

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Statement of Purpose

The purpose of this study is to determine the nonunion rate and extent of displacement of the unfixated Evans calcaneal osteotomy and Cotton medial cuneiform osteotomy in flatfoot reconstruction procedures.

Methodology and Hypothesis

A retrospective review was conducted on all patients who had either an Evans or Cotton osteotomy performed as part of a flatfoot reconstruction procedure done by a single surgeon from 2012 to 2017. Exclusion criteria included any sort of fixation including k-wires, screws, or plates that may have been placed across the osteotomy sites. 42 patients (58 feet) were included in the Evans group and 42 patients (55 feet) were included in the Cotton group. Post-operative serial radiographs were read by a non-objective trained radiologist to determine time to >50% incorporation of the osteotomy/graft interface and degree of any displacement or loss of graft size.

The proposed hypothesis is that the lack of fixation for Evans and Cotton osteotomies does not jeopardize union rates or maintenance of correction.

Procedures

Surgical technique for the Evans osteotomy consisted of the patient in a supine position with approximately a 3 cm incision placed obliquely 1-1.5 cm proximal to the calcaneocuboid joint, confirmed with fluoroscopy. Dissection was carried down to the lateral wall of the calcaneus and a sagittal saw was used to make a lateral to medial cut perpendicular to the lateral calcaneal wall, leaving the medial cortex intact. 2.0 mm Steinmann pins were placed on either side of the osteotomy and a hintermann retractor was used to open the osteotomy site. Correction was dialed in and evaluated clinically using the hintermann so that the patient maintained approximately 2-3 degrees of subtalar eversion. The osteotomy site was measured and either a tricortical iliac crest allograft was fashioned in a triangular shape or a corresponding titanium wedge was placed in the osteotomy site. The hintermann and Steinmann pins were removed allowing compression of the osteotomy site which adequately held the graft in place.

Fig. 1 Incision and osteotomy placement for the Evans osteotomy

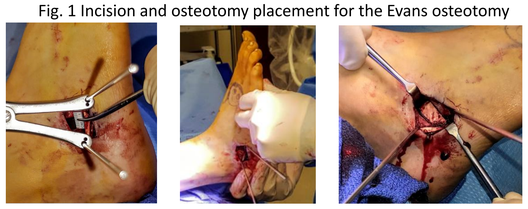

Fig. 2 Measurement of osteotomy site, clinical evaluation of STJ eversion, and compression of graft without fixation

Approximately a 3 cm incision was made over the dorsal aspect of the medial cuneiform. Dissection was carried down to the level of bone and a sagittal saw was used to make a dorsal to plantar cut at the level of the natural lateral flare in the medial cuneiform leaving the plantar cortex intact. 2.0 mm Steinmann pins were placed on either side of the osteotomy and a hintermann retractor was used to open the osteotomy site. The foot was evaluated clinically to dial in forefoot varus correction using the hintermann to increase or decrease correction as needed. The osteotomy site was measured and either a tricortical iliac crest graft or titanium wedge was placed in the osteotomy site and held in place as described above for the Evans osteotomy.

Fig. 3 Incision and osteotomy placement of the Cotton osteotomy and clinical examination of forefoot varus

Fig. 4 Measurement of the osteotomy site, tricortical iliac crest graft shape, and compression of the graft without fixation

Literature Review

Evans and Cotton osteotomies are reliable and frequently used procedures for correction of flexible flatfoot deformities. These procedures are well documented in the literature with continued debate whether fixation is needed for these osteotomies.

A systematic review performed by Prissel and Roukis in 2012 on the incidence of nonunion of the unfixated Evans osteotomy included 5 studies with a total of 73 feet and an overall nonunion rate of 1.4%. John et al. in 2010 looked at Evans osteotomies with use of tricortical iliac crest allograft and found a mean time to graft incorporation of 9.10 weeks in 23 pediatric feet and 9.81 weeks in 34 adult feet and union rates of 100% for pediatrics and 90% for the adult group. None of the osteotomies were fixated in this study. Vosseller et al. in 2013 compared the use of autograft and allograft in Evans osteotomies and found no statistical difference between nonunion rates or loss of correction between the two groups. They reported a nonunion rate of 7.8% in 51 patients in the autograft group and 12% for 75 patients in the allograft group. All patients had some form of screw fixation in this study. In 2015, Gross et al. looked at the use of porous titanium wedges for Evans osteotomies with 96% of the 28 patients having bony incorporation of the titanium wedge at an average of 14.6 months post-operatively. They concluded that porous titanium wedges can be used as an alternative to autograft/allograft for good deformity correction and high union rate with consistent pain relief.

When looking at maintenance of correction, Dayton et al. in 2013 looked at use of a locking plate in preserving positioning of the Evans osteotomy compared to nonfixated osteotomies. They found a mean loss of calcaneal length of 2.45 mm in the 22 nonfixated feet and a mean of 1 mm in the 13 fixated feet at 12 weeks post-operatively. They also found anterior displacement of the calcaneus in 5/22 (23%) of the nonfixated group and 1/13 (8%) of the fixated group. They concluded that locking plates preserve the correction obtained by an Evans osteotomy. Furthermore, Dunn and Meyer in 2011 looked at anterior displacement of the calcaneus after an Evans osteotomy and found a statistically significant dorsal displacement of 1.21. mm of the anterior process at 6 weeks post-operatively. However, this number decreased to an insignificant value of 0.57 mm at the final follow up visit at an average of 35.14 weeks. They conclude that if a plate or screw is used to fixate the Evans osteotomy, the dorsal displacement of the anterior process experienced in the early post-operative period would likely be captured and maintained throughout the healing process, possibly leading to discomfort and/or pain if gradual resorption is not allowed to occur naturally.

The only study looking at nonunion rates of unfixated Cotton osteotomies was done by Brancheau in 2017. This study included 56 pediatric osteotomies with use of tricortical iliac crest allograft. They found that 50 of 56 (87.28%) osteotomies displayed radiographic consolidation at 8 weeks post-operatively, 5 of the remaining 6 went on to consolidate at later times, and the final one had a delayed union that healed uneventfully without complications at 14 weeks. This study conclude that fixation does not influence consolidation rates with adequate maintenance of correction.

Results

Of the 42 patients (58 feet) in the Evans groups, 22 were males and 20 females with an average age of 17.72 years. The Cotton group included 42 patients (55 feet) with 25 males and 17 females with an average age of 19.69 years. 50/58 Evans cases were pediatrics (<18 years old) and 46/55 Cotton cases were pediatrics. Average time to radiographic incorporation was 7.09 weeks with 3 radiographic nonunions (5.17%) in the Evans group and 7.36 weeks with 2 nonunions (3.6%) in the Cotton group as determined by a trained radiologist. 6 patients in the Evans group required revisional surgery due to a clinical nonunion resulting in increased pain at the osteotomy site and 2 patients in the Cotton group required revisional surgery. No significant displacement of the anterior calcaneal process was noted and graft size was adequately maintained in all patients with successful union.

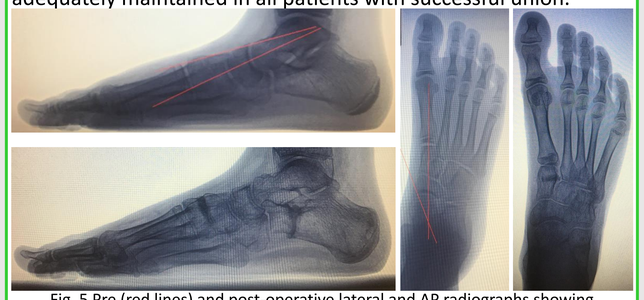

Fig. 5 Pre (red lines) and post-operative lateral and AP radiographs showing significant correction of calcaneal incliniation angle, talar declination angle, meary's angle, kite's angle, talar head uncovering, and cuboid abduction angle

All nonunions occurred in pediatric patients with use of tricortical iliac crest allograft. 3/8 and 3/9 adult cases used titanium wedges rather than tricortical iliac crest allograft.

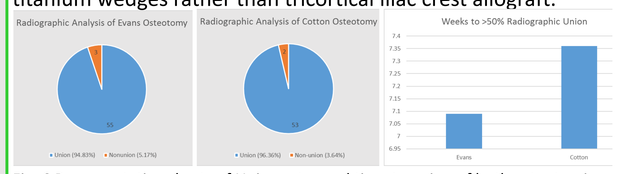

Fig. 6 Representative charts of Union rates and time to union of both osteotomies

Analysis and Discussion

This study shows radiographic nonunion rates of 5.17% for Evans and 3.6% for Cotton osteotomies and corresponding clinical nonunion rates of 10.34% and 3.6% respectively. These rates are comparable to previously reported nonunion rates with use of allograft and fixation across the osteotomy site. The use of fixation across these osteotomy sites increases OR and tourniquet time, cost, and the chance of hardware irritation requiring subsequent surgery. Therefore, unfixated Evans and Cotton osteotomies lead to comparable outcomes with fewer potential complications than their fixated counterparts.

In terms of maintenance of correction, our study showed no anterior displacement or loss of graft size at the date of >50% bony incorporation of the osteotomy/graft interface. This finding contradicts the idea that fixation is needed to maintain lateral column lengthening correction or prevent dorsal migration of the anterior calcaneal process as previously suggested by Dayton et al. Dorsal displacement was not measured in the immediate post-operative period so it is possible that natural subsidence occurred during the post-operative period as previously mentioned by Dunn and Meyer.

In a cadaveric biomechanical study on the long plantar ligament performed by Dinucci et al. in 2004, they measured the tension on the long plantar ligament after placing Evans grafts of 4, 6, 8, 10, and 12 mm. They found maximum tension in the ligament after placing a 6 mm graft and found it very difficult to place an 8 mm graft without sectioning the ligament. They concluded that grafts >6 mm have no additional corrective capacity without compromising the long plantar ligament. In this study, up to 10 mm graft were routinely utilized which may have contributed to some of the graft failures. When using a tricortical iliac crest graft, we found the thickness of the cortical wall to be an important factor when choosing a graft in order to prevent crushing of the graft. Further studies could be done to determine the optimal thickness of cortical wall needed to prevent crushing and maximum graft size that should be utilized before using ancillary procedures to obtain correction.

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