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Effectiveness of a Locking Plate in Preserving Midcalcaneal Length and Positional Outcome after Evans Calcaneal Osteotomy: A Retrospective Pilot Study

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ABSTRACT

When using the Evans calcaneal osteotomy for repair of a calcaneovalgus deformity, lengthening of the lateral column of the foot is the method by which the procedure acts to correct the deformity. Therefore, maintaining the length is a priority. In our experience, substantial length is lost soon after surgery using the traditional nonfixated procedure. To test this hypothesis, a retrospective study was undertaken in which we compared the calcaneal length before and after the Evans procedures in 22 patients treated without fixation and 13 patients in whom the graft was fixated with a small locking plate to bridge the osteotomy and reduce the compressive forces on the graft. Within the first 10 days after surgery, the increase in calcaneal length from the preoperative length was 6.3 mm in the nonfixated group and 6.8 mm in the fixated group ($p = .54$ for the 0.5-mm difference). At 12 weeks after surgery, the mean amount of shortening from the value observed at 1 week was 2.45 (range 0 to 6) mm in the nonfixated group and 1.0 (range 0 to 3) mm in the internal fixation group ($p = .48$). Also, at 12 weeks, distal calcaneal migration or dorsal anterior calcaneal displacement of more than 3 mm occurred in 5 patients (23%) in the nonfixated group and 1 patient (8%) in the fixated group ($p = .04$). Our results suggest that locking plates do preserve the correction obtained with the Evans calcaneal osteotomy.

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The Evans calcaneal osteotomy is a common procedure for treating the flexible calcaneovalgus foot in a variety of patients. Evans (1) believed that a true functional foot is one in which the medial and lateral columns are the same length and that the lateral column has an enormous influence on the shape and function of the foot. In 1959, he developed his lateral column lengthening procedure to treat a calcaneovalgus deformity. This procedure effectively moves the subtalar joint axis laterally, thereby increasing the weightbearing force medial to the subtalar joint axis or creating a net supinatory force. By altering the weightbearing position of both the forefoot and the hindfoot, the procedure corrects hindfoot valgus and midfoot pronation and forefoot abduction (1).

Because the basis of the Evans correction is lateral lengthening, this length must be maintained postoperatively if the procedure is to be effective. To prevent early postoperative loss of calcaneal length and postural changes of the anterior calcaneus in patients treated with an Evans osteotomy, we now fixate the graft with a locking plate. To determine whether this fixation was effective, we retrospectively compared the positional maintenance of the graft in patients undergoing Evans osteotomy with and without fixation at 1 week after surgery and again at 12 weeks, after weightbearing had been initiated.

Patients and Methods

We reviewed the records of all consecutive patients treated with an Evans calcaneal osteotomy, with (Fig. 1) or without fixation at our clinic from January 2005 to December 2008. A standard anterior calcaneal osteotomy was performed on all patients through a lateral incision parallel to and above the peroneal tendons. The osteotomy was performed using a power saw within 2 cm from the calcaneocuboid joint. After distraction, the graft was seated in place. In the nonlocking group, layered closure was then performed. In the fixated group, a small locking plate was applied to bridge the osteotomy and graft.

In all patients studied, gastrocnemius recession was performed through an incision in the central portion of the posterior calf. A tongue and groove slide was made in zone 2 of the fascia, and the foot was dorsiflexed to a minimum of 20° relative to the leg. The lengthening was performed before the osteotomy, and in all cases, the final amount of dorsiflexion was checked after the osteotomy. The lengthening could then be revised if loss of dorsiflexion occurred with the repositioning provided by the osteotomy.

The postoperative protocol specified that the involved foot not bear weight for at least 6 weeks and bear only partial weight while using a cast boot for another 2 to 4 weeks before normal shoes were worn. Radiographic evaluation of each participant was done within the first 10 days postoperatively and at intervals of 2 weeks up to

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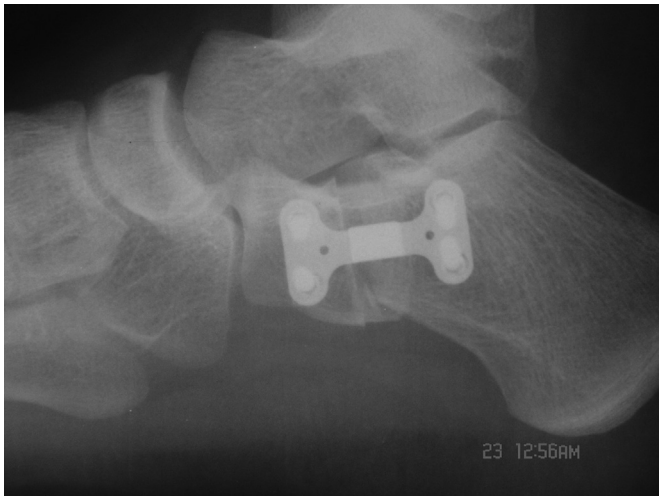

Fig. 1. Standard lateral radiograph showing the osteotomy site and locking plate bridging the graft on a weightbearing right ankle of a 17-year old male 12 weeks after surgery.

12 weeks. The length was measured and displacement of the calcaneus was observed at each visit and recorded in the study records. The endpoint for our study was the 12-week radiographic findings.

The primary outcomes were the postoperative changes in the calcaneal length and the frequency of displacement of the calcaneal fragments. Both were assessed by radiographic examination and chart review. The observers were aware of the purpose of the present study; however, the patient identifiers had been removed. The midcalcaneal length was measured from standard, weightbearing, lateral projection radiographs. According to Dayton et al (2), the midcalcaneal length is the distance between the high point of the convex arc of the most posterior point on the posterior subtalar facet and the low point of the concave arc of the calcaneal cuboid articulation on the calcaneus (Fig. 2). We reduced the variability of measurement by 1 observer (P.D.) performing all the length measurements. The presence of dorsal displacement of the distal calcaneal fragment was determined by inspection of serial lateral radiographs at the intervals noted. The plantar cortical alignment of the distal and proximal portions of the calcaneus was the landmark used to assess the displacement. Visible dorsal displacement of more than 3 mm was recorded as displaced (Fig. 3).

The groups were compared by age using the Student's *t* test and by gender and laterality using the chi-square test. Changes in the calcaneal length and the proportion of patients in whom capital fragments were displaced from 1 week preoperatively to 12 weeks postoperatively were also analyzed using the *t* test and chi-square test, respectively. Alpha was set at 0.05, and all tests were 2-tailed.

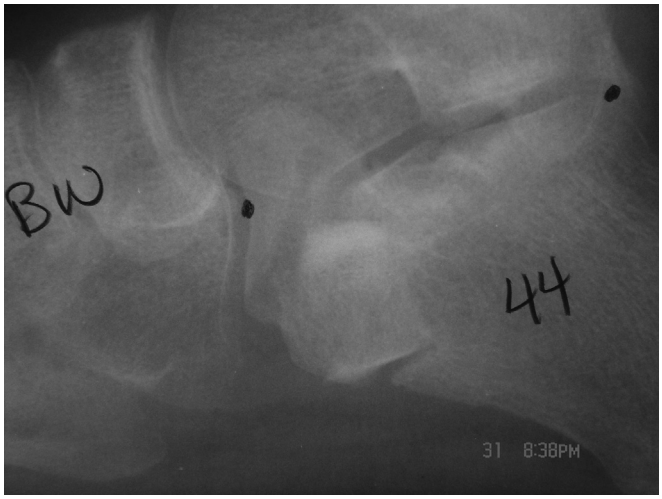

Fig. 2. Midcalcaneal length was measured from the high point of the convex arc of the most posterior point on the posterior subtalar facet to the low point of the concave arc of the calcaneus (2). This standard lateral radiograph of a weightbearing ankle also shows anterior displacement and subsidence of the allograft in an 18-year-old male 11 weeks after surgery.

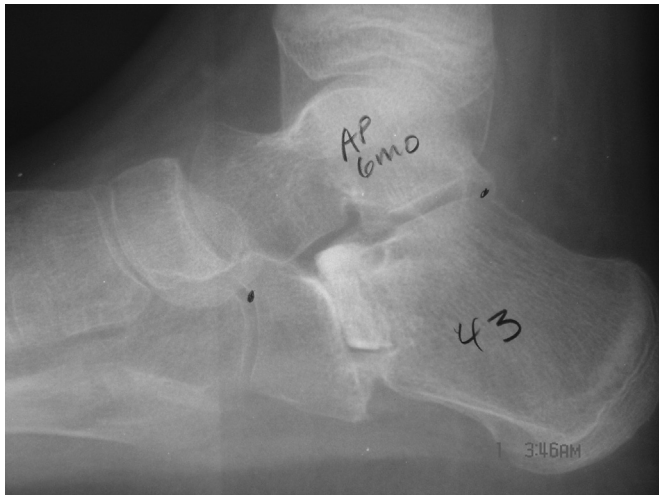

Fig. 3. Standard weightbearing lateral radiographic view demonstrating anterior displacement and subsidence of the allograft that can occur in an Evans calcaneal osteotomy. Also note, the landmarks for the midcalcaneal length measurement.

Results

Of the 81 patients who underwent this procedure during the study period, 55 were excluded because they had required additional foot or ankle procedures other than gastroc soleus recession performed during the Evan procedure. The 26 included patients provided 35 feet for the present study. Of these, 22 feet (16 patients, 9 males) were nonfixated and 13 feet (10 patients, 7 females) were fixated. At surgery, the mean age was 13.9 (range 9 to 50) years in the nonfixated group and 14.9 (range 9 to 33) years in the fixated group. The groups did not differ by age ($p = .69$), gender ($p = .25$), or laterality ($p = .28$).

All the procedures in the nonfixated group were performed by 1 of 3 experienced surgeons, including the primary author (P.D.). All the procedures in the fixated group were performed by the primary author (P.D.) at the same facility. The graft size ranged from 9 to 11 mm (mean 10) in all patients.

The mean length of follow up was 92 (range 88 to 94) days for the nonfixated group and 94 (range 89 to 97) days for the fixated group ($p = .62$). Because the purpose of the present study was to determine the loss of length in the early postoperative period, observations were not recorded past 12 weeks.

At the first postoperative evaluation, the increase in calcaneal length compared with the preoperative length was 6.3 mm in the nonfixated group and 6.8 mm in the fixated group. The mean time to the first postoperative radiographic evaluation was 14 days in the nonfixated group and 9 days in the fixated group. At the second postoperative radiographic evaluation, the mean loss in length was 2.5 mm in the nonfixated group and 1 mm in the fixated group ($p = .048$).

At the first postoperative evaluation, the incidence of anterior displacement of the calcaneus was 2 of 22 (9%) in the nonfixated group and 1 of 13 (8%) in the fixated group ($p = .46$). At the second postoperative evaluation, the incidence had increased to 5 of 22 (23%) in the nonfixated group but had remained at 1 of 13 (8%) in the fixated group ($p = .04$) (Table).

Discussion

The Evans calcaneal osteotomy has been widely used to correct the pathologically pronated foot. Lateral column lengthening and maintenance of the obtained length is paramount to the success of this procedure. We assessed the calcaneal column length to determine

Table
Comparison between non fixated and fixated groups (n = 35 feet; 26 patients)

Variable	Nonfixated Group	Fixated Group
Feet/patients (n)	22/16	13/10
Gender		
Male	9	3
Female	7	7
Age (y)		
Mean	13.9	14.9
Range	9–50	9–53
Graft size (mm)		
Mean	10	10
Range	9–11	9–11
Mean increase in length at first observation (mm)	6.3	6.8
Mean interval to first observation (days)	14	9
Mean decrease in length from first to last observation (mm)		
Mean interval from first to last observation (days)	2.5 (92)	1 (94)
Dorsal calcaneal displacement >3 mm at last observation (%)	23 (5/22)	8 (1/13)

The fixation groups did not differ ($p > .05$) in regard to age, gender, laterality, duration of follow-up, and anterior displacement at the first follow-up; however, loss of length ($p = .048$) and anterior displacement at the last follow-up ($p = .04$) were statistically significantly different.

whether it decreased within 12 weeks after surgery and whether internal fixation with a locking plate prevented or reduced this loss. Our findings suggest that a measurable loss occurs in lateral length, with a greater frequency of anterior displacement, when the osteotomy is not fixated.

In our series of fixated osteotomies, the locking plate protected the allograft by reducing the primary compressive force on the allograft produced by the tension of the soft tissues and also neutralized the angular forces, which can cause anterior fragment displacement. We chose a locking plate instead of a screw, wire, or staple because of its mechanical characteristics of fixed angular stability, which allow it to bridge the osteotomy and maintain multiplanar stability. Locking plates are also more stable in cancellous bone and in unicortical applications and are therefore well suited to calcaneal fixation. We hypothesized that the locking plate would preserve the length of the lateral column, and our data have supported that hypothesis. The locking plate also reduced the frequency of dorsal anterior displacement of the calcaneus. In the present study, the first measurements were not taken until the first postoperative visit. This raises the possibility that the length changed between surgery and the first measurement, and, therefore, we might have underestimated the loss of length in the nonfixated group.

The Evans calcaneal osteotomy uses several biomechanical principles to maintain the longitudinal arch during weightbearing, as described by Dollard et al (3). Adducting the forefoot by lengthening the lateral column will act to reverse the abducted forefoot position, promote the midtarsal locking mechanism, re-establish the forefoot position, and improve talonavicular alignment (3). The main goal for performing a lateral lengthening procedure is to redistribute the weightbearing forces on the foot, thereby improving foot stability and reducing pain (4). A key requirement for the procedure to be successful is that the midfoot and forefoot must be flexible and reducible. Because the longitudinal arch changes during the first 7 years in life, the procedure should ideally be performed after the eighth year of life. Performing the procedure before skeletal maturity can allow for potential bone remodeling (1). Although it is common to select this procedure for children, lateral lengthening can also be used to help correct acquired flexible flatfoot in adults (5). In the original procedure described by Evans, a trapezoidal tricortical iliac crest autograft 8 to 12 mm wide is inserted 1.5 cm proximally to the calcaneocuboid joint. This recommendation remains consistent today. Maintenance of the lateral lengthening and prevention of displacement are the key reasons for our recommendation to fixate the osteotomy.

Sangeorzan et al (6) established normal standing radiographic values for the planovalgus position and the positional changes seen after an Evans calcaneal osteotomy. The investigators concluded that the procedure increases the lateral talocalcaneal angle 6° to 7°; the talometatarsal angle by up to 12°, as measured on the lateral radiographic view, and up to 16°, as measured on the anteroposterior radiographic view; and the calcaneal inclination angle up to 11°. In addition, the procedure improves the alignment of the talus and navicular by about 26°, with a 1-cm-wide allograft. They showed that the procedure, not only corrects the forefoot position without operating on the medial side of the foot, but also that talus and navicular alignment is a sensitive indicator of collapse (6). We believe that maintenance of the lateral lengthening will prevent undercorrection, which we have seen with our unfixated procedures. We have attributed this undercorrection to the loss of graft length or graft subsidence into the calcaneus.

Other studies have considered the clinical outcomes of the procedure. The longest of these studies had a mean follow-up of 13 years. That study, by Phillips (7), the results of which were later validated by Mosca (8), reported that 17 of 23 patients (74%) had good or very good radiographic and functional results and that the patients were able to return to their full activities of daily living. The contribution of the amount of lengthening to the overall correction has not been widely studied, and we have very little information regarding the absolute length required to achieve optimal function. Most surgeons will assess the graft length clinically at surgery by putting the foot through the full range of motion and thereby determine whether the stability is adequate by palpation and fluoroscopy of the midtarsal and subtalar joints. Once the final graft has been placed, the loss of graft length would reduce the corrective influence of the lateral lengthening on the midfoot and hindfoot. This change might not be readily evident, but it could become apparent late in the recovery period as an undercorrection of the deformity. Sangeorzan et al (6) stated in their review that "It is not clear why the absolute measurement of the length of the calcaneus did not mirror the increased length of the added bone graft." They did not define their method of measuring the overall length of the calcaneus, and no other studies have considered the overall postoperative length of the calcaneus. In our series, the loss of the midcalcaneal length (2) was noted in the first 12 weeks and had resulted from graft collapse and subsidence of the graft into the calcaneus when the osteotomy was not fixated. This, along with the increase incidence of displacement of the anterior portion of the calcaneus, makes a compelling argument for the use of fixation. Because the displacement forces on the osteotomy site are both angular and compressive, we believe a locking plate provides the most stable construct to prevent both subsidence and displacement.

Equinus is a key consideration in surgical planning for the Evans procedure and must be addressed for the procedure to be successful. Patients can lose up to 15° of dorsiflexion after lateral lengthening, the amount of correction of the calcaneal inclination obtained after lengthening (9). Therefore, posterior lengthening is necessary if tightness of the posterior muscle group is present. We commonly perform the posterior lengthening before the calcaneal osteotomy and then check the ankle dorsiflexion after the osteotomy. It is sometimes surprising the amount of dorsiflexion that is lost after repositioning of the hindfoot and midfoot with the Evans procedure. Surgical planning must also consider the metatarsus adductus deformity, because the procedure can accentuate the deformity (3).

Complications of the Evans procedure have included excess calcaneocuboid joint pressures and arthrosis (10,11), impaction of the graft into the subtalar joint (3), dorsal displacement of the distal calcaneal fragment (9), overlengthening, forefoot adduction, persistent forefoot supination (1), peroneal tendonitis (3), and stress fractures of the fifth metatarsal (3). We believe that fixation of the

osteotomy with a locking plate, in addition to meticulous surgical technique, will result in fewer complications.

The follow-up period for the present study was less than what would be acceptable for an outcomes study. However, we did not intend to evaluate the long-term efficacy of the procedure but only to test the feasibility of using a locking plate to maintain mid-calcaneal length and to reduce the incidence of anterior displacement in the early postoperative period. Thus, we believe the short period did not compromise the findings related to length loss and displacement.

In conclusion, our results suggest that locking plates preserve the correction obtained using the Evans calcaneal osteotomy when treating the flexible valgus foot. We believe that future studies, if properly designed and controlled, could help determine whether preserving the net lateral column length obtained is important in maintaining the function and biomechanics of the foot and further validate the utility of the fixated Evans procedure.

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