

Radiographic Outcomes Following Utilization of Size Varied, Pre-shaped Allograft Wedges for Lateral Column Lengthening as an Isolated Procedure in a Cadaver Model

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Study Purpose

- To determine the radiographic effect of graft size and shape used in an Evans osteotomy as an isolated procedure.
- The mechanisms of deformity reduction are not fully understood, and often the procedure is not done in isolation. Better patient outcomes may be obtained by understanding the radiographic changes and incorporating them into pre-operative planning.

Hypothesis

- There will be a significant difference between pre-procedural and post-procedural radiographic values in the sagittal, transverse and frontal planes.
- No difference will be shown between the corrections obtained with the use of Cotton pre-shaped wedges in comparison to Evans pre-shaped wedges.

Methods

A cadaveric study was performed using 6 adult specimens. A pes planovalgus foot type was generated, and an Evans osteotomy was performed. Pre-procedural and post-procedural radiographs were taken and measured. Post-procedural radiographs were taken using size and shape varied graft sizers.

Procedure

A medial incision was instituted proximally at the medial malleolus and continued distal to the navicular tuberosity. The posterior tibial tendon was then transected to generate a pes planovalgus foot type. Simulated weightbearing pre-procedural radiographs then taken: AP, Lateral, and Calcaneal Axial.

Pre-procedural and post-procedural radiograph measurements included: AP: Kite's angle, Meary's angle (forefoot abduction), Cuboid abduction; Lateral: Calcaneal inclination, Talar declination, Lateral Meary's angle; Calcaneal Axial: Hindfoot varus/valgus.

A sagittal saw was then used to create an Evans osteotomy oriented perpendicular to the lateral surface of the calcaneus, as well as perpendicular to the weight-bearing surface, extending between the anterior and middle facets of the subtalar joint. The osteotomy was made parallel to the calcaneal cuboid joint. An osteotome was then used to complete the osteotomy medially. A bow distractor was then used to distract the osteotomy site.

The graft sizers were then introduced. Each cadaver had a 6mm, 8mm, 10mm and 12mm Evans wedge sizer and a 5mm, 6mm, 7mm and 8mm Cotton wedge sizer inserted into the osteotomy site. Following the insertion of each sizer, radiographs were then taken and measurements were recorded.



Figure 1: Resection of posterior tibial tendon (left). Evans osteotomy placement 1.0-1.5mm proximal to the calcaneal-cuboid joint with a bow distractor inserted into the osteotomy site (center). Frontal view and dorsal views of the Evans and Cotton shaped sizers that were inserted into the osteotomy site (right).

Literature Review

Evans reported that the Evans osteotomy lengthened the lateral column, as well as decreased forefoot and rearfoot valgus¹. Previous cadaver studies have shown evidence that the Z calcaneal lengthening may also correct a percentage of the hindfoot valgus component when used as an isolated procedure². The Evans osteotomy has been researched in terms of biomechanical effect relative to graft shape, vital structures encountered during dissection, including the anterior and medial facets, and predicted graft size based on digital templating^{3,4,5}. Research has also shown that rectangular grafts redistribute talonavicular joint pressure better than trapezoidal grafts⁴.

DuMontier et al, proposed that the clinical appearance of the post-procedural hindfoot varus is secondary to the forefoot adduction and position of the calcaneus and talus at the posterior facet⁶. They believe there is external rotation of the calcaneus following a lateral column lengthening where the forefoot is adducted relative to the hindfoot, thus, creating a varus hindfoot. In a study by Campbell et al, graft shape was also analyzed with the use of 6 cadaver models in which they compared rectangular grafts versus a wedge shaped trapezoidal graft positioned 3 ways; lateral, dorsal and plantar⁴. They found that the rectangular shaped grafts, with increased bone graft volume medially, corrected the medial arch collapse and forefoot abduction better than a trapezoidal graft.

In looking at graft size comparisons, Chan et al performed a retrospective analysis of 41 patients who underwent the Evans procedure, as well as other procedures often used in flatfoot reconstruction, to reduce talonavicular abduction⁷. They found that there was a linear regression model between the graft size and the lateral incongruity angle with a R² value of 0.70. In that, there was a 6.8 degree difference in the lateral incongruity angle from pre to post-procedure.

Sangeorzan et al completed a retrospective analysis of pre and post-operative radiographs for 7 patients who had an isolated Evans procedure with a 1cm iliac crest corticocancellous graft inserted⁸. Their study demonstrated that despite a 1cm graft used, the average increase in calcaneus length was only 4mm post-operatively. They also noted that the talonavicular coverage angle improved by 26 degrees and calcaneal inclination increased by 11 degrees.

Despite current research, to date, there is little known in terms of the amount of correction gained radiographically, and in which planes, from an Evans osteotomy as an isolated procedure relative to the size and shape of the allograft used.

Results

- There was a statistical difference shown (paired t-test, SPSS version 22) in all graft sizes from pre to post-procedure radiographs for the Cotton and Evans for Cuboid abduction, Calcaneal inclination, and Hindfoot varus/valgus.
- Overall, there was no significant difference in Talar declination for either graft type. No difference was shown in the 5mm Cotton and 6mm Evans grafts in deformity reduction in the Kite's angle (p=0.203).
- AP Meary's angle showed a significant change in radiographic measurements with the use of 7 and 8mm Cotton grafts, as well as 8, 10 and 12mm Evans grafts. The 5 and 6mm Cotton grafts, as well as the 6mm Evans graft, only had a 0.5 degree change from pre-procedure to graft insertion (p=0.203, 0.076). The Lateral Meary's angle was not statistically different using the 5mm Cotton graft or the Evans 6mm and 8mm grafts (p=0.076).
- Paired t-tests were not significantly different between Cotton and Evans wedges of the same size, 6mm and 8mm, except for Hindfoot varus/valgus. The Cotton wedge created more correction with a mean difference of 2.0 degrees greater than the Evans for an 8mm graft (p=0.033).

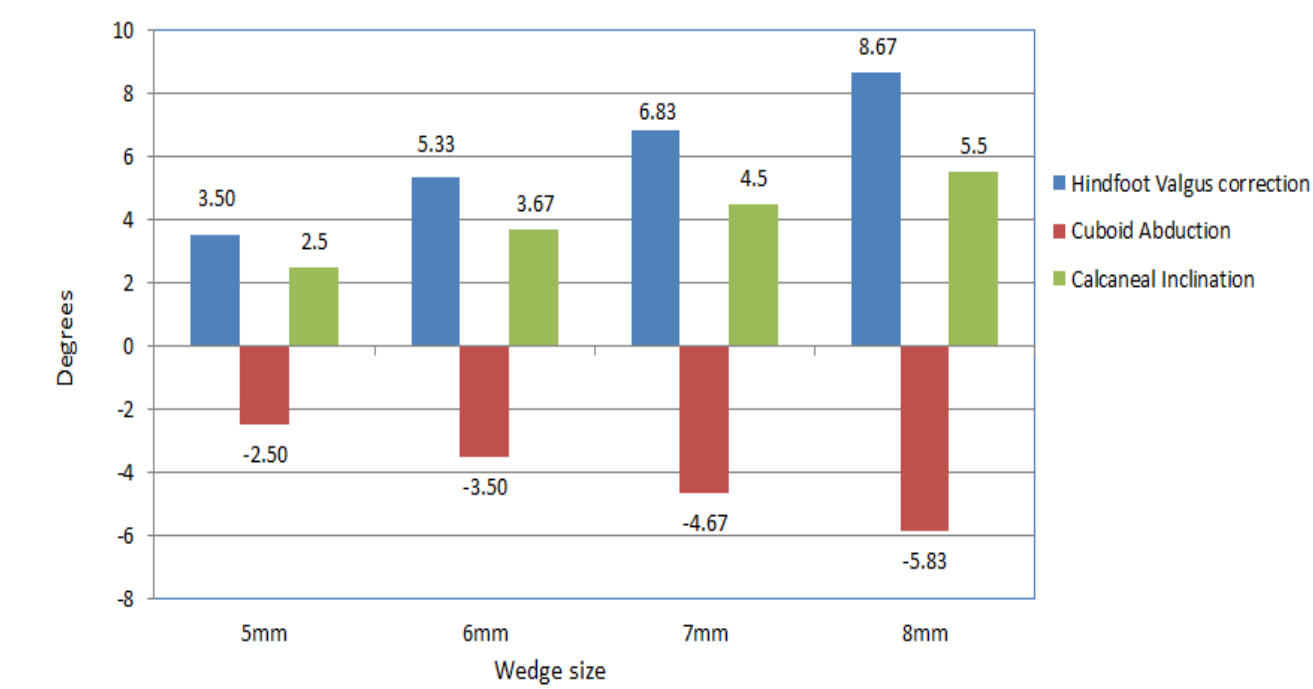
Mean Change in Pre-procedure to Post-procedure Radiographic Measurements											
	Cotton Graft				P	Evans Graft				P	
	5mm	6mm	7mm	8mm		6mm	8mm	10mm	12mm		
AP	Kite's	-0.50	-0.83	-1.33	-1.67	P=0.003	-0.50	-1.00	-1.67	-1.83	P=0.000
	Meary's	-0.50	-0.50	-1.00	-1.33	P=0.001	-0.50	-1.17	-1.33	-1.50	P=0.006
	Cuboid Abduction	-2.50	-3.50	-4.67	-5.83	P=0.000	-3.00	-4.67	-6.00	-7.50	P=0.000
Lateral	Calcaneal Inclination	2.50	3.67	4.50	5.50	P=0.000	3.67	4.67	5.33	6.17	P=0.000
	Talar Declination	0.00	-0.33	-0.33	-0.50	P=0.299	0.00	0.00	-0.17	-0.33	P=1.95
	Lateral Meary's	0.50	1.00	1.33	1.67	P=0.001	0.50	1.00	1.33	1.67	P=0.001
Calcaneal Axial											
Hindfoot varus/valgus	3.50	5.33	6.83	8.67	P=0.000	4.00	6.67	8.50	10.33	P=0.000	

Table 1: Mean difference, in degrees, between pre- to post-procedure radiographs following insertion of size varied Evans and Cotton pre-shaped grafts. P-values are based on repeated measure analysis. P < 0.05 are significantly different from pre-procedural measurements.



Figure 3: Pre and post-procedure radiographs demonstrating radiographic correction obtained in the frontal and transverse planes using a 12mm Evans graft sizer.

Mean change in Radiographic Values with Cotton wedge



Mean change in Radiographic Values with Evans wedge

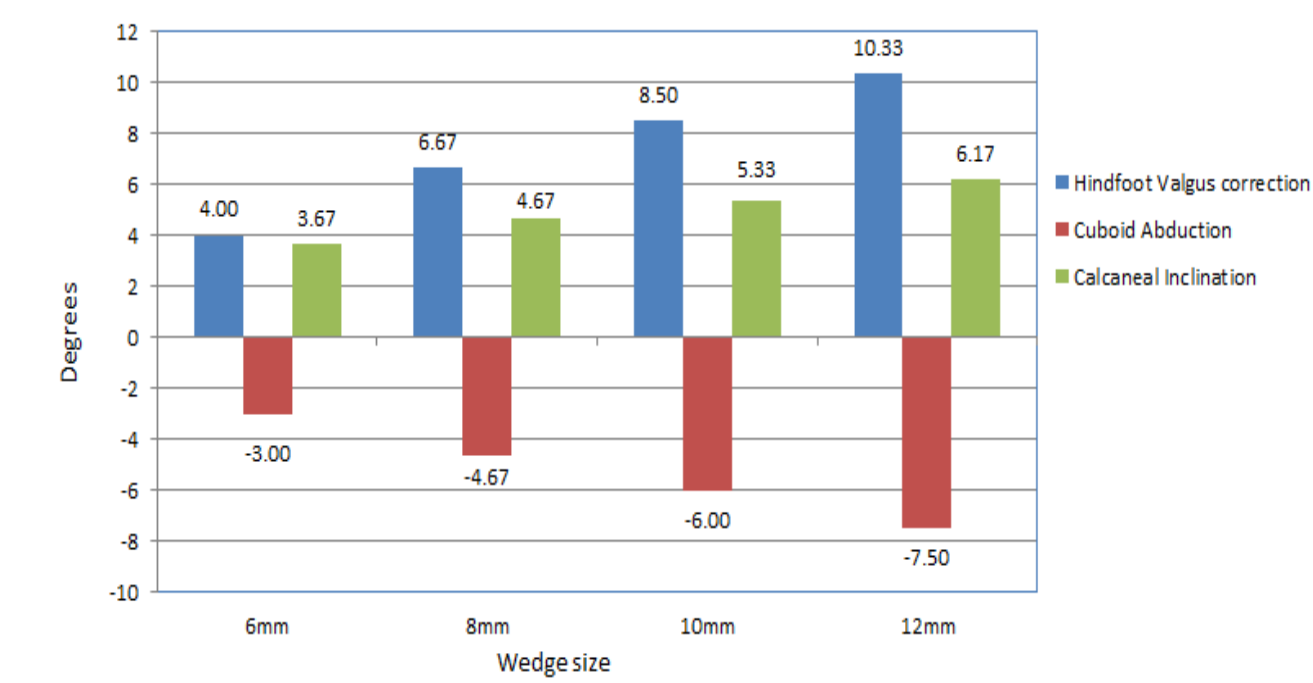


Figure 2: Histograms showing the mean difference in radiographic measurements of Hindfoot varus/valgus, Cuboid abduction and Calcaneal inclination angles from pre to post-procedure using size varied Cotton (top) and Evans (bottom) grafts.

Discussion

Our results suggest tri-planar correction of a flatfoot can be obtained with the use of Evans or Cotton pre-shaped grafts. The insertion of all the grafts used, led to a significant change in the Cuboid abduction, Hindfoot varus/valgus and Calcaneal inclination angles compared to pre-procedural. The smaller grafts, for both the Evans and the Cotton shapes, were not all able to statistically change the other radiographic measurements (Kite's, AP and Lateral Meary's angles), but larger graft sizes were. Talar declination was not significantly affected using either graft type of any size.

In the current study, paired t-tests were not significantly different between Cotton versus Evans wedges of the same size, except for Hindfoot varus/valgus, where the 8mm Cotton wedge resulted in 2 degrees more deformity correction. This could possibly be secondary to the Cotton graft's length being greater than that of the Evans, thus allowing for an increased lever arm for deformity reduction, All graft shapes and sizes lead to a significant reduction in Hindfoot valgus.

Our study only found an average increase in the Calcaneal inclination angle of 5.3 degrees when using a 10mm Evans wedge compared to Sangeorzan's, which found an increase of 11 degrees⁸. Sangeorzan proposed that the long plantar ligament is able to elevate the arch after an Evans osteotomy by acting as a windlass mechanism, contributing to the change seen on post-procedural radiographs⁹. Chan's study was able to show a linear regression between graft size and post-procedural angle measurement, Consistent with our study, the larger the graft size, the greater the radiographic change between pre to post-procedural measurements in some parameters, but not all.

Conclusion

- This study showed that as an isolated procedure, the Evans osteotomy is able to perform tri-planar correction of flatfoot parameters using both Evans and Cotton pre-shaped allograft wedges.
- From this study, increased understanding of radiographic correction was obtained to propose that an Evans osteotomy could be one of the first procedures done in a flatfoot reconstruction sequence, as it allows significant multi-planar correction.
- We demonstrated that the Cotton shaped wedges, of identical width to the Evans wedges, had better correction of Hindfoot valgus deformity, and that increase in graft size does not always lead to a proportional deformity reduction in every radiographic measurement.

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