

# The Use of Tricortical Autograft Versus Allograft in Lateral Column Lengthening for Adult Acquired Flatfoot Deformity: An Analysis of Union Rates and Complications

Kathleen M. Grier, MD<sup>1</sup> and Arthur K. Walling, MD<sup>2</sup>  
Omaha, NE

## ABSTRACT

**Background:** The management of adult acquired flatfoot is an evolving practice with the optimal lateral column lengthening procedure still left to considerable debate. The usual choices include lengthening with the use of autograft or allograft through a calcaneocuboid lengthening arthrodesis or Evans' calcaneal lengthening osteotomy. To our knowledge there is only one other study comparing autograft to allograft in adult lateral column lengthening procedures.<sup>9</sup> The purpose of this study was to evaluate differences with regard to union rates and complications when comparing the use of iliac tricortical autograft versus iliac tricortical allograft supplemented with platelet rich plasma (PRP) in adult acquired flatfoot lateral column lengthening procedures. **Materials and Methods:** The charts and radiographs of 49 patients (51 feet) were evaluated. Twenty total procedures were performed using iliac tricortical autograft and 31 procedures were performed using iliac tricortical allograft with PRP. **Results:** Successful union was achieved in 14 of 20 (70%) autograft procedures and 29 of 31 (94%) allograft procedures. Thirteen of 20 (65%) of the autograft group and 11 of 31 (35%) of the allograft group had a documented complication other than nonunion. Average length of hospital stay for patients who had procedures using autograft was 3.6 days and those who had allograft was 2.5 days. The average charge for those receiving allograft with PRP, including hospital stay, was roughly \$2,500 more than those receiving an autograft procedure. **Conclusion:** Although the numbers were small, we believe that equivalent if not better healing and complication rates are possible with the use of allograft with PRP versus autograft for lateral column lengthening procedures while allowing for similar correction of deformity.

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Corresponding Author:  
Kathleen M. Grier, MD  
GIKK Ortho Specialists  
7710 Mercy Road  
Omaha, NE 68124  
Email: kthubley@hotmail.com

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## Level of Evidence: III, Case Control Study

**Key Words:** Lateral Column Lengthening; Autograft; Allograft; Union Rate

## INTRODUCTION

The most appropriate treatment for adult acquired flatfoot with typical stage 2b deformity (flexible) in patients with posterior tibial insufficiency has not been established. Depending on the degree and site of deformity, multiple treatment strategies exist. When indicated, some type of lateral column lengthening procedure is typically employed as part of the surgical correction. This can be accomplished by use of either a calcaneocuboid lengthening arthrodesis or a calcaneal lengthening osteotomy. Earlier reports have discussed either calcaneocuboid lengthening or Evan's lengthening without a clear indication of which procedure is most effective in obtaining correction.<sup>3,12,18,21</sup> However, these reports do identify a potential problem of higher nonunion rates with use of the calcaneocuboid arthrodesis.<sup>3,4,21</sup>

Toolan et al. reported their results with regard to nonunion when using autograft with calcaneocuboid arthrodesis. One study reported eight nonunions (20%) out of 36 patients treated with lateral column lengthening and iliac crest autograft with calcaneocuboid arthrodesis.<sup>21</sup> A second study reported eight nonunions out of 48 (16%) using the same technique.<sup>3</sup> Conti and Wong reported ten out of 32 nonunions (31%) using iliac crest autograft at the calcaneocuboid joint.<sup>4</sup>

When comparing these results with lengthening procedures using an Evans' calcaneal osteotomy, the literature has shown a lower nonunion rate with the use of Evans' calcaneal osteotomy. Pomeroy and Manoli reported no nonunions out of 20 lateral column lengthening procedures using iliac crest autograft and Evans' osteotomy.<sup>18</sup> Hinterman et al. reported one nonunion out of 19 (5%) patients treated with lateral

column lengthening using iliac crest autograft and Evans' osteotomy.<sup>12</sup>

Historically, the graft of choice for these lateral column lengthening procedures, irrespective of location, has been tricortical iliac crest autograft. To our knowledge, there is only one published report in the adult literature comparing the use of autograft versus allograft in lateral column lengthening. Dolan et al. reported their results with the use of autograft versus allograft with Evans' calcaneal osteotomy. All patients in their study progressed to union regardless of graft type with slightly faster union rates found with allograft.<sup>9</sup>

Comparisons of the use of autograft and allograft in lateral column lengthening procedures have been reported in the pediatric literature. Mosca reported no nonunions out of 31 lateral column lengthening procedures in children with flatfoot and skewfoot using both autograft (7) and allograft (24) in Evans' osteotomies.<sup>14</sup> Danko et al. reported on graft collapse in lateral column lengthening procedures for children with planovalgus foot deformities. Although nonunion was not specifically addressed, they found better results with an osteotomy regardless of the use of autograft or allograft and no collapse with autograft regardless of placement at the calcaneocuboid joint or in an Evan's osteotomy.<sup>6</sup> However, the pediatric population has obvious differences to the adult population and therefore may not be an ideal population with which to compare.

The purpose of this study was to compare the results of the use of iliac tricortical allograft supplemented with PRP to iliac tricortical autograft when performing lateral column lengthening procedures associated with the correction of stage 2b (flexible) adult acquired flatfoot deformities.

## MATERIALS AND METHODS

A consecutive series of patients between 1996 and 2006 were reviewed. All patients were treated according to a specific algorithm for correction of their deformity (Table 1). All patients required lateral column lengthening as part of their correction; however, the location of the lengthening varied. It was performed either as a calcaneocuboid lengthening arthrodesis or as an Evan's calcaneal lengthening osteotomy. Trocortical allograft (with PRP supplementation) and tricortical autograft were compared at each site.

A retrospective review of clinic and hospital charts as well as pre- and postoperative radiographs was performed. A series of 49 consecutive patients with 51 adult acquired flat feet were studied. Average age was 57 (range, 24 to 75) years at time of surgery. Patient followup averaged 20 (range, 3 to 72) months. In comparing autograft versus allograft irrespective of site, 20 total procedures were performed using tricortical autograft and 31 total procedures were performed using tricortical allograft and platelet rich plasma (PRP). When comparing the site of lateral column lengthening, irrespective of type of graft used, we performed a

**Table 1:** Summary of Nonunions Including Site and Graft

Graft	Site	Non-		Total	Nonunion Rate
		Union	union		
Autograft		14	6	20	30%
	C-C	5	5	10	50%
	Evans	9	1	10	10%
Allograft +PRP		29	2	31	6%
	C-C	21	2	23	8.6%
	Evans	8	0	8	0%

total of 33 calcaneocuboid lengthening arthrodeses and 18 Evan's calcaneal lengthening osteotomies. Ten total lateral column lengthening procedures were performed using tricortical autograft with Evans' calcaneal lengthening osteotomy (range, 39 to 72 years of age). Twenty-three total procedures were performed using tricortical allograft and PRP at the calcaneocuboid joint (age, 42 to 72 years of age).

Charts were reviewed for comorbidities, etiology of flatfoot, hospital course, length of hospital stay, additional surgical procedures, complications, and re-operations. Radiographs were reviewed for pre- and postoperative medial cuneiform to fifth metatarsal distance, talonavicular distance, anterior-posterior talo-first metatarsal angle, lateral talo-first metatarsal angle and calcaneal pitch.

Lengthening with a calcaneocuboid arthrodesis was performed using the following surgical technique. A longitudinal incision was made over the calcaneocuboid joint with care to protect the peroneal tendons and sural nerve. The joint was then debrided of articular cartilage and a lamina spreader was used to lengthen the column through the joint. The separation needed to correct the deformity was measured and the graft (whether auto- or allograft) was cut to this measurement. The graft was then impacted into place and fixed with an H-plate and screws (Synthes®). Plate fixation at this site was felt to be necessary as previous experience with more limited fixation had shown an unacceptably high nonunion rate.

When utilizing the Evan's calcaneal lengthening osteotomy, an incision over the anterior process of the calcaneus paralleling the peroneal tendons was made. A transverse osteotomy was then created 1.2 cm from the calcaneocuboid joint. A lamina spreader was similarly used to open the osteotomy, it was measured and the graft (auto- or allograft) was appropriately sized. The graft was then impacted and fixed with a single 3.5 cortical lag screw from distal to proximal into the body of the calcaneus. It was not felt that the amount of fixation required for the calcaneocuboid lengthening was necessary at this site.

Tricortical iliac crest autograft was harvested in a standard fashion from the iliac wing. An appropriately sized graft was harvested from the widest part of the wing.

Allograft procedures were performed using freeze-dried tricortical iliac allograft (LifeLink®) supplemented with GPS platelet rich plasma concentrate (Biomet®) obtained from 60 cc of patient blood. The graft was soaked in the concentrate.

Because of the nature of stage 2b flatfoot deformities, additional soft tissue- and bone procedures were performed in conjunction with the lateral column lengthenings; however, these procedures were standardized and performed without respect to the type of lengthening or the use of auto- or allograft. All but three patients had flexor digitorum longus (FDL) tendon transfers. These three patients had accessory naviculars with the pathology at the level of the accessory navicular. In these three patients the accessory navicular was removed and the remained of the posterior tibial tendon was advanced into the true navicular. It was not felt that supplemental FDL transfer was needed. Three patients also demonstrated midfoot sag at the first metatarsal medial cuneiform joint (first MTC) on lateral radiographs and had first MTC fusions in addition to their medial soft-tissue procedure. A gastrocnemius recession or tendoachilles lengthening (TAL) was performed in all patients. If, following the choice of the lengthening procedure, there was felt to be residual valgus of the hindfoot, a medializing calcaneal tuberosity sliding osteotomy was included.

Nonunions were identified both clinically and radiographically. Clinically, patients complained of persistent pain and swelling on the lateral border of the foot after weightbearing. Radiographically, lucency at either of the graft interfaces or broken hardware were noted in the patients with nonunions.

Statistical differences between the groups were calculated using Fisher's Exact Test and Paired t-tests. Significance was defined as  $p < 0.05$ .

**RESULTS**

Fourteen of 20 (70%) of the autograft procedures progressed to union versus 29 of 31 (94%) of the allograft procedures ( $p = 0.045$ ) (Table 2). Nonunions became apparent at 5 to 6 months, typically by the time the patients had progressed to full weightbearing in a regular shoe.

Twenty-six of 33 (79%) of the calcaneocuboid arthrodeses progressed to union versus 17 of 18 (95%) of Evans' calcaneal osteotomy ( $p = 0.233$ ) (Table 3).

When comparing the type of graft used, irrespective of site of lengthening, the highest number of nonunions was found in the autograft group performed at the calcaneocuboid joint. Ten total lateral column lengthening procedures were performed using tricortical autograft at the calcaneal cuboid joint (age range, 44 to 75 years of age) resulting in a nonunion rate of 5 of 10 or 50% at this site. Two of the nonunions were noted radiographically but the patients were asymptomatic and required no further surgery. The remaining three did require further surgery and were converted to triple arthrodeses. One patient was noted to have broken hardware

and loss of correction (Figure 1), another had persistent pain and swelling clinically and the last had persistent lateral symptoms. None of those patients requiring re-operation were smokers or had diabetes. One of the patients with an asymptomatic nonunion was a smoker.

Only one nonunion in the lateral column lengthening autograft group was found resulting in a nonunion rate of one of ten or 10%. This patient was found to have broken hardware, loss of correction and lucency at both graft interfaces (Figure 2). This patient required revision (with allograft and supplemental PRP) and went on to uneventful healing. This patient had no comorbidities and was not a smoker.

Two nonunions occurred in the allograft calcaneocuboid fusion group resulting in a nonunion rate of two of 23, or 8.6%. One patient underwent revision of their nonunion which failed to heal and was then converted to a triple arthrodesis with subsequent removal of hardware at which time the triple arthrodesis was found to be solid. The second non-union in this group was noted with broken hardware and loss of correction documented on CT scan but was overall asymptomatic and required (Table 3) no further surgery (Figure 3). Neither of these patients were smokers and neither had other comorbidities.

All of the Evans' calcaneal lengthening procedures using allograft went on to uneventful healing. No nonunions were noted in this group of which eight procedures were performed (age range, 24 to 69 years of age).

Average improvement in lateral talo-first metatarsal angle and calcaneal pitch in patients who had autograft at the calcaneocuboid joint was 20.2 degrees and 10.3 degrees, respectively. Average improvement in those who had allograft at the calcaneocuboid joint was 16.2 degrees and 8.0 degrees, respectively. Average improvement in those who had autograft with Evans' was 14.0 degrees and 7.2 degrees,

**Table 2:** Graft Specific Union Rate Irrespective of Site

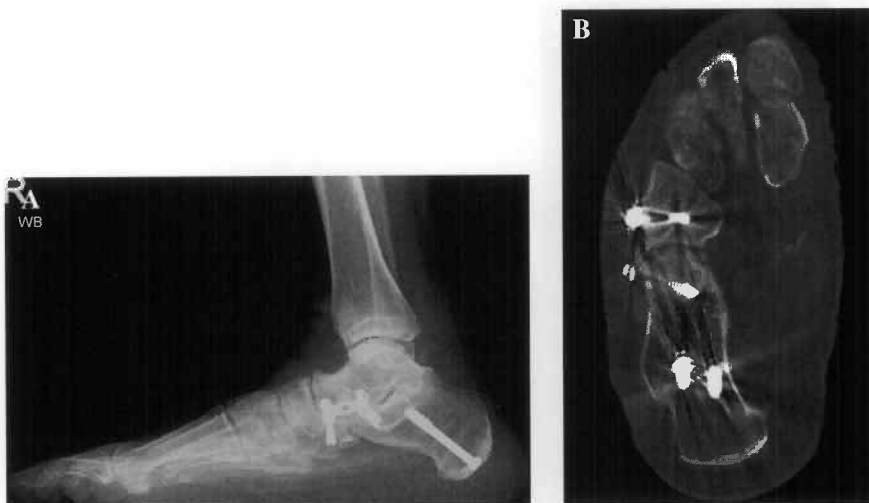
Graft	Union	Nonunion	Total	Union Rate
Autograft	14	6	20	70%
Allograft+PRP	29	2	31	94%

**Table 3:** Site-Specific Unions Irrespective of Type of Graft

Arthrodesis Site	Union	Nonunion	Total	Union Rate
Calcaneocuboid	26	7	33	79%
Evans	17	1	18	95%



**Fig. 1:** Autograft/Evans 3-months postoperative with persistent lucency at graft site. Films at 5 months revealed broken screw but films lost.



**Fig. 2:** A, Allograft/CC Arthrodesis Nonunion. B, Same patient with CT confirmation of nonunion at distal interface of CC joint.

respectively. Average improvement in those who had allograft with Evans' was 16.8 degrees and 6.8 degrees, respectively. No statistical significance was found when comparing calcaneocuboid procedures to Evans procedures or autograft procedures to allograft procedures (range,  $p = 0.1694$  to  $0.8764$ ) (Figures 4 to 7).

### Complications

Combining all autograft procedures, 13 of 20 (65%) had documented complications aside from nonunion. These included minor complications of: superficial wound infections (5) all treated successfully with Keflex, sural nerve paresthesias (2), broken hardware (2), painful hardware (2) and ICBG harvest site tenderness (2). Major complications included: ICBG harvest site herniation (1) and iliac

wing fracture after ICBG harvest (1) (Figure 8). There were no documented complaints of neuralgia paresthetica.

Combining all allograft procedures, 11 of 31 (35%) had a documented complication other than nonunion. These were all minor and included a superficial wound infection (1) treated successfully with Keflex, sural nerve paresthesias (1), broken hardware (5) and painful hardware (4). The difference in complications was found to be significant ( $p = 0.049$ ).

### FINANCIAL IMPLICATIONS

Average length of hospital stay for patients who had procedures using autograft was 3.6 days and those who had allograft was 2.5 days. The average charge for a hospital



**Fig. 3:** A and B, Autograft/CC joint 3 months postoperative. C and D, Same patient noted to have broken hardware and loss of correction 22 months postoperative. No interval clinic visit.

day admission at our institution is \$1400. The charge to the patient for the PRP and allograft is \$4,364 (Applicator \$304.00, Platelet processing kit \$1,560, and iliac bone block \$2,500) and the Medicare reimbursement in Florida for an ICBG harvest is \$509. Taking these charges into account and accounting for the additional hospital day stay for autograft procedures, on average, the cost for an allograft procedure with supplemental PRP was approximately \$2,315 more than for autograft.

## DISCUSSION

The original intent of this study was to explore the possibility of using iliac tricortical allograft as an alternative to iliac crest autograft when performing lateral column lengthening procedures for the correction of adult acquired flat-foot deformities. Younger and Chapman reported rates of major and minor complication of 5.3% and 25%, respectively, at the anterior iliac crest donor site. By their criteria

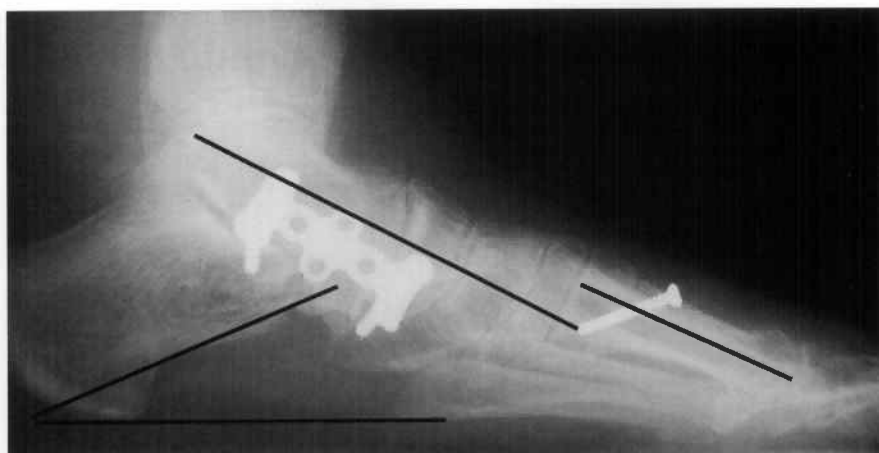


Fig. 4: Auto/CC with uneventful union and restoration of medial column and calcaneal pitch.

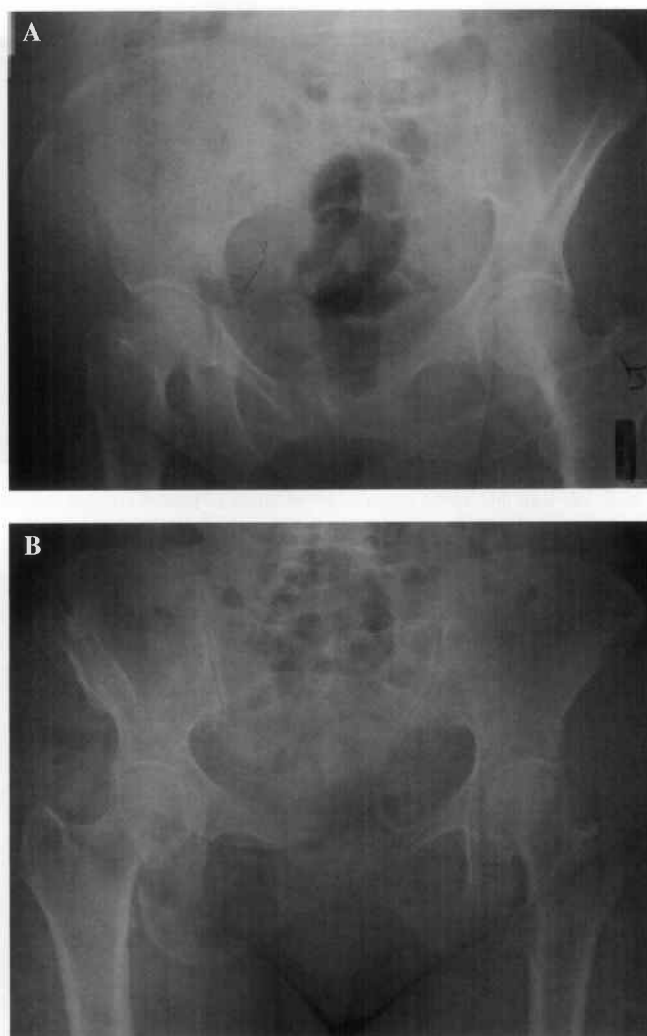


Fig. 5: A, Right iliac wing fracture 21 days postoperative at ICBG harvest site. B, Same patient 2 years postoperative.

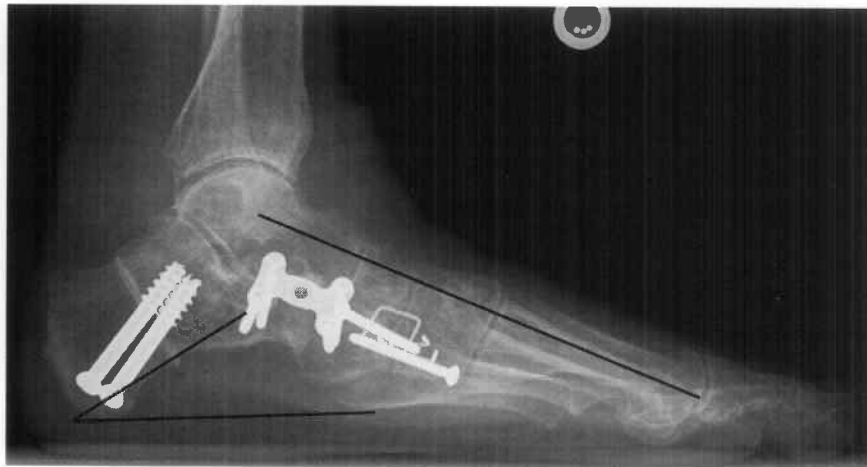


Fig. 6: Allo/CC arthrodesis with uneventful union and restoration of the medial column (lateral talar-first metatarsal angle) and calcaneal pitch.



Fig. 7: Allo/Evans with uneventful union and restoration of medial column and calcaneal pitch.



Fig. 8: Auto/Evans with uneventful union and restoration of medial column and calcaneal pitch.

**Table 4:** All Calcaneocuboid Lengthening Arthrodeses, Associated Procedures and Unions

Patient	Graft	FDL	Medial Column Fusions	Medial Calcaneal Shift	Achilles	Union	Complications
1	Auto	Yes			TAL	No	
2	Auto	Yes			TAL	Yes	
3	Auto	Yes			TAL	Yes	
4	Auto	Yes			TAL	Yes	
5	Auto	Yes			TAL	No	
6	Auto	Yes			TAL	No	
7	Auto	Yes			TAL	Yes	
8	Auto	Yes			TAL	Yes	
9	Auto	Yes			TAL	No	
10	Auto	Yes		Yes	Strayer	No	
11	Allo	Kidner		Yes	Strayer	Yes	
12	Allo	Yes			Strayer	Yes	
13	Allo	Yes			Strayer	Yes	
14	Allo	Yes		Yes	Strayer	Yes	
15	Allo	Yes			Strayer	Yes	
16	Allo	Yes			Strayer	Yes	
17	Allo	Yes		Yes	Strayer	Yes	
18	Allo	Yes		Yes	Strayer	Yes	
19	Allo	Yes		Yes	Strayer	Yes	
20	Allo	Yes		Yes	Strayer	Yes	
21	Allo	Yes		Yes	Strayer	Yes	
22	Allo	Yes			Strayer	Yes	
23	Allo	Kidner			Strayer	Yes	
24	Allo	Yes			Strayer	No	
25	Allo	Yes		Yes	Strayer	Yes	
26	Allo	Yes	N-C		Strayer	Yes	
27	Allo	Yes		Yes	Strayer	Yes	
28	Allo	Yes	1 <sup>st</sup> MTC	Yes	Strayer	Yes	
29	Allo	Yes			Strayer	Yes	
30	Allo	Yes			Strayer	No	
31	Allo	Yes			Strayer	Yes	
32	Allo	Yes			Strayer	Yes	
33	Allo	Yes			Strayer	Yes	

major complications included residual numbness, abdominal hernia, and residual pain. Minor complications were defined as superficial hematomas, temporary sensory disturbances and mild pain. Other potential complications include infection and fracture.<sup>22</sup>

Four of 13 (31%) of the complications in the autograft group in our study were directly attributable to the ICBG donor site. In our series there were complaints of tenderness at the graft harvest site up to a year and a half after surgery in two patients. One patient went on to have a hernia repair at the site of harvest and most significantly, one patient sustained an iliac wing fracture at the site of harvest 3 weeks after surgery (Figure 8). No further surgical intervention was needed for the fracture but this patient continued to complain of pain 2 years

after surgery. It may be that complaints of tenderness at the graft harvest site, whether they are bothersome or not, may well be higher but these were the only patients whose complaints were documented in the chart. Certainly, these complaints and complications are eliminated with the use of allograft.

It is also likely that the additional average day of hospital stay for patients undergoing an autograft procedure is due to the additional pain from the graft harvest site. With the use of allograft, we could anticipate earlier discharge of patients undergoing these procedures.

Because of our concern regarding the potential for higher nonunion rates with the use of allograft, a decision was made to supplement the tricortical iliac allograft with PRP in an attempt to make it "as close to autograft" as possible. Whether



**Table 5:** All Calcaneal Lengthenings (Evan's Procedures), Associated Procedures, and Unions

Patient	Graft	FDL	Medial Column Fusions	Medial Calcaneal Shift	Achilles	Union	Complications
1	Auto	Yes			TAL	Yes	
2	Auto	Yes			TAL	Yes	
3	Auto	Yes			TAL	Yes	
4	Auto	Yes			Strayer	Yes	
5	Auto	Yes			Strayer	Yes	
6	Auto	Yes		Yes	Strayer	Yes	
7	Auto	Yes			Strayer	Yes	
8	Auto	Yes			Strayer	Yes	
9	Auto	Yes		Yes	Strayer	Yes	
10	Auto	Yes			Strayer	No	
11	Allo	Yes			Strayer	Yes	
12	Allo	Yes			Strayer	Yes	
13	Allo	Yes		Yes	Strayer	Yes	
14	Allo	Yes		Yes	Strayer	Yes	
15	Allo	Yes		Yes	Strayer	Yes	
16	Allo	Yes		Yes	Strayer	Yes	
17	Allo	Yes			Strayer	Yes	
18	Allo	Yes	1 <sup>st</sup> MTC		Strayer	Yes	

this supposition is true or not is beyond the scope of this paper.

From the standpoint of graft incorporation (94% versus 70%) and morbidity (35% versus 65%), this study provides evidence that the use of allograft with PRP supplementation provides at least equivalent if not better graft material for lateral column lengthening procedures commonly used in the correction of flexible stage 2b foot deformities.

The use of allograft with PRP is further supported in our series by the similar correction obtained with regard to lateral talo-first metatarsal angle and calcaneal pitch when compared to autograft. No statistical significance was found when comparing graft used or site used. The similar correction obtained regardless of graft used demonstrates that allograft with PRP, when used for lateral column

lengthening, effectively corrects the malalignment of the midfoot and hindfoot associated with flatfoot deformities as described by Toolan et al. in their description of dorsolateral peritalar subluxation and the abnormal biplanar relationship between the talus and the navicular resulting from attrition or rupture of the posterior tibial tendon.<sup>21</sup>

We were also able to compare the two most common sites for performing lateral column lengthening. As previously mentioned, the decision to perform the lengthening through a calcaneocuboid lengthening arthrodesis or through the use of an Evans' calcaneal lengthening osteotomy is based on surgeon preference and controversy has existed with regard to which procedure is best. Correction potential and alterations in the forces and motion through the adjacent hindfoot joints are the most commonly debated questions. With the Evans' osteotomy, there is concern regarding alteration of the forces through the calcaneocuboid joint articulation and increasing the chance for secondary arthritic changes at this joint as well as altering the forces through the subtalar joint and precipitating arthritic changes there as well.<sup>5,15,16</sup> Alternatively, with the calcaneocuboid joint arthrodesis, the forces can be increased more distally such as at the fifth metatarsocuboid articulation thereby precipitating pain and arthrosis at this level. We have had patients with both these complications. However, when comparing radiographic parameters of correction at both sites, irrespective of type of graft used for the lengthening, there were no statistical differences between the location of the lengthening.

The largest difference between sites has been a higher nonunion rate at the calcaneocuboid arthrodesis site. Our

**Table 6:** Average (AVG) and Standard Deviation (SD) Improvement in Lateral Talo-First Metatarsal Angle and Calcaneal Pitch

Site/Graft	Lateral Talo-first Improvement AVG/STD	Calcaneal Pitch Improvement AVG/STD
CC/Auto	20.2°/(9.6)	10.3°/(5.8)
CC/Allo	16.2°/(7.9)	8.0°/(4.2)
Evans'/Auto	14.0°/(8.2)	7.2°/(6.0)
Evans'/Allo	16.8°/(8.1)	6.8°/(5.6)

experience during this review has mirrored that of the literature. Previously, our inclination was to perform calcaneocuboid lengthening arthrodeses for correction; however, with minimal fixation techniques (simple screw fixation), we experienced an unacceptably high nonunion rate. Thus we began using supplemental plate and screw fixation which we thought would eliminate the nonunion problem. Unfortunately this assumption was not correct. Despite the additional fixation with autograft our nonunion rate was 50%. While our nonunion rate was less with the use of allograft plus PRP (8.6%), it is still higher than that found with the Evan's calcaneal lengthening osteotomies. Thus, we believe that the use of an Evan's osteotomy, with an overall union rate of 95% may be preferential to calcaneocuboid arthrodesis with an overall union rate of 79%.

An acknowledged drawback to this study is that not all patients had exactly the same surgical procedure, due to the variability of pathology encountered in the treatment of flatfoot deformity even when limited to stage 2b deformities. However, all patients were treated according to the same algorithm by the same surgeon. The concomitant procedures were equally distributed between the autograft and allograft with PRP groups and had no statistical effect on the union rates. The fixation methods did differ by site, but there was no difference between fixation for autograft or allograft with PRP at each site. An additional concern is the relatively small numbers especially in the allograft with PRP Evan's calcaneal osteotomy lengthening group; however, our experience mirrors the larger study by Dolan et al.<sup>9</sup> Despite these drawbacks we feel this study demonstrated the suitability of allograft with PRP supplementation as an alternative for lateral column lengthening.

## CONCLUSION

We propose that the use of allograft with PRP supplementation for lateral column lengthening procedures is a reasonable alternative to the use of autograft with regard to higher union rates, lower complication rates, and similar correction potential at a slightly higher cost.

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