

Long-Term Functional Outcomes of Resected Tarsal Coalitions

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Abstract

Background: There are few long-term studies evaluating tarsal coalition resections. The purpose of this study was to compare patient outcomes following resection of calcaneonavicular (CN) and talocalcaneal (TC) bars and to determine the relationship between the extent of a coalition and the outcome of resection.

Methods: Patients younger than 18 years receiving resection for symptomatic tarsal coalition (1991-2004 inclusive) were eligible to participate. Follow-up evaluation included clinical examination to assess range of motion and self-reported functional outcome questionnaires. Two validated functional scales were used: the American Academy of Orthopaedic Surgeons (AAOS) Foot and Ankle Module, and the Foot Function Index (FFI). Twenty-four patients with 32 tarsal coalition resections (19 CN and 13 TC feet) were included in this study. For CN and TC patients, the mean age at the time of surgery was 11.8 ± 1.1 and 11.9 ± 2.5 years, and the mean age at follow-up was 27.1 ± 1.1 and 25.0 ± 2.5 years, respectively.

Results: Inversion and eversion were significantly less for TC feet when compared with CN ($P = .03$ and $P = .01$, respectively). No difference was noted between the CN and TC groups with respect to outcome scores. Furthermore, no association was noted between the size of TC coalition or hindfoot valgus angle with respect to outcome scores.

Conclusion: Resected CN and TC bars behaved similarly in the long term in terms of function and patient satisfaction. Favorable results were attained when resections were performed on TC coalitions that were greater than 50% of the posterior facet and hindfoot valgus angles greater than 16 degrees.

Level of Evidence: Level III, retrospective comparative study.

Keywords: pediatric, outcome studies, statistical analysis, tarsal coalition, resection

Tarsal coalition is a congenital anomaly whereby the bones of the hindfoot and midfoot are fused.⁹ Although the condition affects approximately 1% to 2% of the population, only 25% of patients are estimated to be symptomatic.^{10,18} A unifactorial autosomal dominant pattern of inheritance with variable penetrance has been suggested, with approximately 50% bilaterality.^{14,24} Calcaneonavicular (CN) and talocalcaneal (TC) bars are the 2 most common types, accounting for 90% of all coalitions, with clinical presentation normally between 10 to 12 and 12 to 16 years of age, respectively.^{6,25}

Patients who are symptomatic may experience pain, spasm, limited range of motion, and frequent foot or ankle injuries.¹³ Such complaints are generally localized to the subtalar joint and are aggravated with increased activity.^{11,17} In some patients, there may be other associated deformities as hindfoot valgus, out-toeing, and flattening of the arch.¹⁷ The goal of treatment is pain relief and improvement in function. Nonoperative approaches (ie, activity modification, nonsteroidal anti-inflammatory drugs, shoe orthotics, physical therapy, and short leg walking casts) are often the first line treatment.^{6,10,22} For those patients who do not

respond to conservative treatment and continue to have pain and disability, surgery may be an option. Saxena and Erickson²¹ reported that patients who had operative resection, compared with nonoperative treatment, had a greater level of activity and higher percentage of return to sports. The role of resection as primary treatment is controversial. However, arthrodesis is usually performed for patients with large coalitions, failed resection, or advanced degenerative changes.^{2,10}

There is currently no clear consensus on the operative criteria leading to favorable outcomes. Attempts to associate features of a coalition (ie, age of patient, composition of

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coalition, graft material, presence of C-sign or talar beaking) with functional outcomes and patient satisfaction have produced equivocal results.¹³ This may be attributable to differences in patient characteristics, coalition characterization, and time to follow-up and the lack of validated outcome assessments. Some authors have advocated primary arthrodesis, either subtalar or triple, for TC coalitions with a surface area greater than 50%, which is calculated as a percentage of the total cross-sectional area of the coalition against the area of the posterior facet.^{5,27} Furthermore, it is unknown whether CN bar resections have better outcomes than TC bar resections.

The purpose of this study was to compare patient outcome following resection of CN and TC bars and to determine the relationship between the extent of a coalition and the outcome of resection.

Methods

Approval was obtained from the Hospital for Sick Children Research Ethics Board prior to study commencement. We identified all patients younger than 18 years treated by resection for symptomatic tarsal coalition at the Hospital for Sick Children between 1991 and 2004. Patients who had concurrent subtalar or triple arthrodesis were excluded. None of the patients had any other associated foot or ankle anomalies such as fibular or tibial hemimelia, juvenile inflammatory arthropathy, or neuromuscular conditions. A total of 60 patients were identified and contacted to participate. Twenty-four patients with a combined 32 operative resections were willing to participate in the study (8 patients with bilateral resections). Our enrollment rate was 40% (24/60). Reasons for nonparticipation included need for follow-up visit, distance from our institution, and lack of interest. Nineteen CN feet and 13 TC feet were included in this study. Eight patients had bilateral resections and no patients had both CN and TC coalition within one foot. For CN patients, the mean age at the time of resection and follow-up was 11.8 ± 1.1 and 27.1 ± 1.1 years, respectively, and for TC patients, 11.9 ± 2.5 and 25.0 ± 2.5 years.

The health records of all study patients were reviewed to determine demographics, age at time of surgery, type of coalition, procedure performed, postoperative course, and complications. Radiographs and computed tomography (CT) scans were used to verify the characteristics of the fusion. The relative size of the TC coalition with respect to the posterior facet was calculated from preoperative CT scans, as described by Wilde et al.²⁷ Hindfoot valgus was also determined as described by Wilde et al.²⁷ Preoperative CT scans were unavailable for 4 TC resections (4 patients).

To determine the functional outcome of our adult patients, 2 validated scales were used: the American Academy of Orthopaedic Surgeons (AAOS) Foot and Ankle Module (0 = poor to 100 = excellent) and the Foot Function

Index (FFI) (0 = excellent to 100 = poor). The AAOS Foot and Ankle Module contains 2 scales: the Foot and Ankle Core Scale (FACS) and Shoe Comfort Scale (SCS). The FACS is a 20-item scale to measure pain, function, and stiffness, whereas the SCS is a 5-item scale for the ability to wear different types of shoes comfortably. The module was initially validated in an adult patient population with a variety of foot and ankle pathological conditions.¹³ The FFI is a 23-item scale to measure pain, disability, and activity restriction. It was initially validated in an adult patient population with rheumatoid arthritis.³ Both instruments have since been validated for other populations.^{1,4,8,23,26} SooHoo et al²³ reported that the FFI had a moderate to high level of correlation with the Short Form-36 Health Survey, allowing it to serve as a validated measure of health status for adults.²³ Similarly, the reliability, validity, and sensitivity to change for the AAOS-FACS and SCS have been demonstrated by Johanson et al.¹² Three patients with a total of 4 resections were unable to return to the clinic for a follow-up visit and were asked to return the completed questionnaires by mail.

Clinical examination of range of motion (plantar flexion, dorsiflexion, inversion, and eversion) was performed by one individual (a senior orthopedic resident) using a goniometer at the follow-up visit. All patients were prone on a clinical examination table with 90 degrees of flexion at the ipsilateral knee. Plantar flexion and dorsiflexion were measured as the arc of motion between the line from first metatarsal head to the heel pad and the long axis of the tibia, as described by Luhmann and Schoenecker.¹⁵ Subtalar motion was measured as the arc of motion relative to a line from the long axis of the lower leg as it bisects the Achilles tendon.⁷

Statistical analyses were performed using SAS software version 9.1 (SAS Institute, Cary, NC) with the type I error probability (alpha) preset at 0.05. Data were evaluated using paired *t* tests for continuous data and Fisher's 2-tailed exact test or the Pearson chi-square test for categorical data. To assess correlation, we determined Pearson correlation coefficients. All study data were collected with respect to laterality and the patient as a whole. For patients who received bilateral resections, we considered each procedure individually. However, functional outcomes were analyzed with respect to the patient as a whole, as recommended by Menz.¹⁶

Results

The 9 available preoperative CT scans showed that the average hindfoot valgus of patients with TC bars was 19.8 ± 10.5 degrees, with 5 bars being less than or equal to 16 degrees (mean, 11.8 ± 4.7 degrees) and 4 bars being greater than 16 degrees (mean, 23.1 ± 5.5 degrees). The average size of TC bars with respect to the posterior facet was 57.6% $\pm 23.0\%$, with 4 bars less than 50% (mean, $40.0\% \pm 4.7\%$)

Table 1. Preoperative Characteristics of All Study Patients.

Baseline Characteristics	Type of Coalition		All Patients
	Calcaneonavicular	Talocalcaneal	
No. of patients	13	11	24
No. of resections	19	13	32
Age at resection, y			
Mean $\pm$ SD	11.8 $\pm$ 1.1	11.9 $\pm$ 2.5	11.8 $\pm$ 1.8
Median	12.0	12.0	12.0
Minimum	10.0	8.0	8.0
Maximum	13.0	16.0	16.0
Side			
Right	8	7	15
Left	11	6	17
Composition			
Osseous	5	5	10
Cartilage	5	4	9
Fibrocartilage	5	1	6
Unknown	4	3	7
Hindfoot valgus, degrees			
Mean $\pm$ SD	24.2 $\pm$ 13.2	16.8 $\pm$ 7.6	19.8 $\pm$ 10.5
Median	25.9	14.9	17.4
Minimum	2.2	3.8	2.2
Maximum	37.7	29.5	37.7
Relative size of coalition to posterior facet, %			
Mean $\pm$ SD		57.6 $\pm$ 23.0	57.6 $\pm$ 23.0
Median		51.0	51.0
Minimum		34.1	34.1
Maximum		100.0	100.0

$P < .05$.

and 5 bars equal to or greater than 50% (mean, 71.7% $\pm$ 22.0%) (Table 1).

In terms of operative technique, 18 of the 19 CN resections used extensor digitorum brevis (EDB) as interpositional graft. Of the 13 TC resections performed, 7 used fat or wax as interpositional material, 4 used flexor digitorum longus (FDL), 1 used flexor hallucis longus (FHL), and 1 did not use any material. Concomitant operative procedures performed included tendo-Achilles lengthening (TAL) and Dwyer calcaneal osteotomy. Only 1 TAL procedure was performed, and this was in the CN group. Both the CN and TC groups had 1 concomitant calcaneal osteotomy performed. Only 1 postoperative complication was reported, an early wound infection treated with oral antibiotics in the TC group (Table 2).

At follow-up, no difference could be detected with respect to range of ankle motion between the 2 groups in plantar flexion and dorsiflexion. Subtalar motion (inversion and eversion) was significantly less for TC feet compared with CN feet ($P = .03$ and $P = .01$, respectively) (Table 3).

No difference was noted between the CN and TC groups with respect to all 3 questionnaires (Table 3). No correlation

was noted between the outcome scores and size of TC coalitions (AAOS-FACS score, $r = -0.53$; FFI score, $r = -0.18$) (Figure 1). Similar results were attained when the AAOS-SCS outcome scores were plotted against coalition size.

Furthermore, TC coalitions with hindfoot valgus less or equal to 16 degrees had comparable outcomes to those greater than 16 degrees (AAOS FACS score, 72.6 $\pm$ 25.4 vs 84.8 $\pm$ 10.2, respectively, $P = .40$; FFI score, 21.5 $\pm$ 17.5 vs 24.7 $\pm$ 18.1, respectively, $P = .80$). No correlation was noted between AAOS-FACS or FFI scores and preoperative hindfoot valgus for TC coalitions, irrespective of coalition size (AAOC-FACS score, $r = 0.30$; FFI score, $r = 0.01$).

Discussion

Surgery for CN or TC coalitions is an option when patients have ongoing persistent pain and nonoperative treatments have failed.² This study is unique in that we followed a large number of symptomatic tarsal coalitions treated operatively and evaluated their outcome using validated instruments an average of 14.4 years after surgery. This study demonstrated that for young adults after surgical resection, the majority of

Table 2. Operative Characteristics of All Resections.

Operative Characteristics	Type of Coalition		All Patients
	Calcaneonavicular	Talocalcaneal	
No. of resections	19	13	32
Time to follow-up, y			
Mean $\pm$ SD	15.3 $\pm$ 4.3	13.1 $\pm$ 3.6	14.4 $\pm$ 4.1
Median	16.0	13.0	15.3
Minimum	6.9	9.3	6.9
Maximum	20.3	19.7	20.3
Interposition graft material, No.			
Fat/wax	1	7	8
Extensor digitorum brevis	18	0	18
Flexor digitorum longus	0	4	4
Flexor hallucis longus	0	1	1
None	0	1	1
Calcaneal osteotomy, No.			
Yes	1	1	2
No	18	12	30
Tendo-Achilles lengthening, No.			
Yes	1	0	1
No	18	13	31
Postoperative complications, No.			
None	19	12	31
Early wound infection	0	1	1

$P < .05$.

Table 3. Follow-Up Physical Examination (n = 21) and Outcome Measures (n = 24) for Study Patients^a.

Follow-Up	Type of Coalition		P Value	All Patients
	Calcaneonavicular	Talocalcaneal		
Plantar flexion, degrees				
Mean	22.7 $\pm$ 4.0	21.4 $\pm$ 7.5	.6	22.1 $\pm$ 5.5
Median	20.0	20.0	20.0	
Dorsiflexion, degrees				
Mean	13.5 $\pm$ 4.2	12.7 $\pm$ 5.6	.7	13.2 $\pm$ 4.8
Median	10.0	15.0	12.5	
Inversion, degrees				
Mean	10.9 $\pm$ 4.4 ^b	6.8 $\pm$ 4.6 ^b	.0 ^b	9.3 $\pm$ 4.9
Median	10.0	5.0	10.0	
Eversion, degrees				
Mean	10.0 $\pm$ 4.0 ^b	5.5 $\pm$ 3.5 ^b	.01 ^b	8.2 $\pm$ 4.4
Median	10.0	5.0	5.0	
AAOS-FACS				
Mean	83.6 $\pm$ 17.7	79.0 $\pm$ 17.2	.5	81.8 $\pm$ 17.4
Median	89.0	82.0	84.5	
AAOS-SCS				
Mean	76.8 $\pm$ 29.1	74.3 $\pm$ 34.7	.8	75.8 $\pm$ 30.8
Median	100.0	90.0	100.0	
FFI				
Mean	19.5 $\pm$ 20.0	20.8 $\pm$ 15.6	.9	20.0 $\pm$ 18.1
Median	8.2	17.7	14.7	

Two validated scales were used: the American Academy of Orthopaedic Surgeons (AAOS) Foot and Ankle Module (0 = poor to 100 = excellent) and the Foot Function Index (FFI) (0 = excellent to 100 = poor). The AAOS Foot and Ankle Module contains 2 scales: the Foot and Ankle Core Scale (FACS) and Shoe Comfort Scale (SCS).

^b $P < .05$.

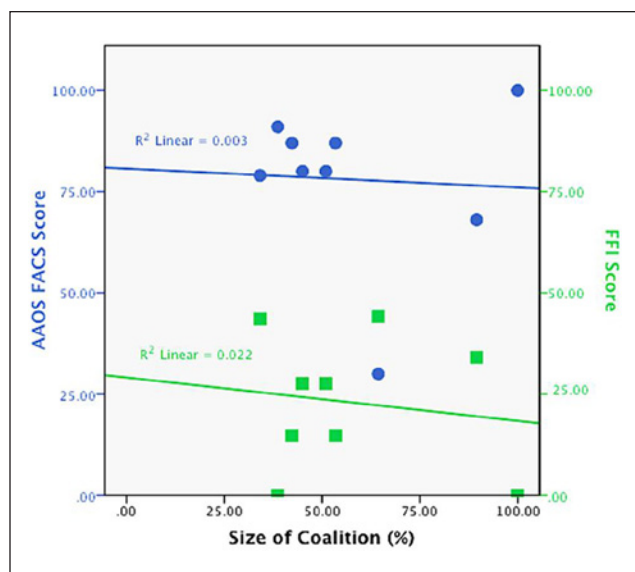


Figure 1. Plots of American Academy of Orthopaedic Surgeons Foot and Ankle Core Scale (AAOS-FACS, circles) and Foot Function Index (FFI, squares) on y-axis against relative preoperative size of talocalcaneal coalition on x-axis ($n = 9$).

patients had relatively little pain and few functional limitations. Our results are consistent with previous studies reporting good to excellent results with the use of resection and interpositional graft for both TC and CN coalitions.^{5,7,13,19,27} As noted above, however, most studies had a relatively short follow-up period. Because of the nature of this condition and the patient population (mean follow-up of 14.4 ± 4.1 years and mean age at follow-up of 26.2 ± 1.8 years), our patients were assessed at an age when they would expect to be quite active.

It is often thought that CN resections result in better outcomes compared with TC resections. In this study, patients with resected CN and TC bars reported similar function and pain. Our findings support those of Saxena and Erikson,²¹ who reported no noteworthy difference in the return to activity time following CN and TC resections. Although the authors reported that some surgically treated patients reported a less than desired activity level, the number of patients who ultimately quit their sport was much higher in the nonoperative group compared with the operative group (11 vs 2).

Wilde et al,²⁷ using visual analogue scales for pain and disability, reported fair or poor results in 7 out of 17 feet in which the size of TC coalition was greater than 50% with respect to the posterior facet. The authors considered these coalitions as “unsuitable for resection” and recommended that primary arthrodesis be performed. Luhmann and Schoenecker¹⁵ reported an association between TC coalitions greater than 50% in size and worse outcomes, quantified using the American Orthopaedic Foot & Ankle Society (AOFAS) hindfoot score. Both studies defined the size of

the coalition and hindfoot valgus using the same criteria that we used here. However, the outcome follow-up was relatively short term, and one study did not use a validated outcome measure scale. The sample size in our study was comparable to that of the abovementioned studies, particularly for TC coalitions greater than 50% of surface area. Even if the outcomes are related to the size of the coalition, no study has demonstrated that primary arthrodesis provides better results. It should be noted that the criterion for successful resection of TC coalitions less than 50% in size was arbitrarily established.²²

In contrast to previous studies, we demonstrated excellent long-term functional outcomes for patients who have greater than 50% TC coalition surface area.^{5,27} An interesting finding, although not statistically significant, was that patients treated with resection for larger TC coalitions had better functional outcomes (AAOS-FACS score, $P = .44$; FFI score, $P = .83$). Given the findings of this study, the dogma that arthrodesis is the first-line treatment for TC coalitions greater than 50% needs to be questioned. Triple arthrodesis has been reported to lead to stress transfer to the ankle joint in the long term.²⁰ Furthermore, resection when performed as an initial procedure does not exclude the possibility of a future arthrodesis, if needed.

This study has several limitations. First, this was a retrospective case series; thus, we did not have preoperative functional outcomes. However, all patients received validated outcome scales at follow-up in a consistent fashion. Second, because of lack of institutional review board approval, no follow-up imaging of patients was undertaken so postoperative degenerative changes could not be evaluated. Nonetheless, the focus of this study was to assess long-term pain relief and function. Third, we did not have preoperative range of motion documentation, so a comparison with postoperative status could not be performed. However, Hetsroni et al¹¹ demonstrated that both TC and CN bar excision do not recreate normal foot kinematics. In fact, similar restrictions in subtalar motion were observed in patients with and without resection during gait analysis. Similar to our results, high AOFAS scores were documented immediately following surgical resection for tarsal coalitions, indicating notable functional improvements for patients. Finally, our sample size was limited. Yet considering the nature of this condition and the age group of patients at follow-up, our sample size is in keeping with other reported series.^{15,18,27}

In conclusion, our results suggest that primary arthrodesis may not be necessary as initial treatment and that resection should be considered irrespective of coalition size. Furthermore, resected CN and TC bars behave similarly in the long term. Favorable long-term results were attained with resections performed on TC coalitions larger than 50% in surface area and hindfoot valgus angle greater than 16 degrees.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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