

Cavovarus Foot Surgery Including a Peroneus Longus Transfer: A 2- to 6-Year Follow-up

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Abstract

Background: The primary aim of this longitudinal study was to describe patient satisfaction and clinical outcome at least 2 years following cavovarus foot surgery, utilizing a peroneus longus to brevis transfer, lateral ligament reconstruction, and corrective osteotomies of the first metatarsal, occasionally with the added calcaneal osteotomy.

Methods: Sixteen patients (17 feet) were examined in 2010-2012, 3.5 (range, 2-6.5) years after cavovarus foot surgery performed in 2004-2010 utilizing a peroneus longus to brevis transfer, lateral ligament reconstruction, and osteotomy of the first metatarsal with or without additional calcaneal osteotomy. The mean age at surgery was 45 years. Evaluation at baseline before surgery and at follow-up assessed patient satisfaction, using the American Orthopaedic Foot & Ankle Society (AOFAS) hindfoot score. At follow-up, visual analog scale (VAS) score for pain at walking was recorded, and a clinical and radiographic evaluation was included.

Results: The mean AOFAS score improved from 57 (SD 11) to 83 (SD 12.5) points, with an average score improvement of 25 score points (95% confidence interval 16-35, $P < .0001$). Postoperative VAS score for pain at walking was mean 2 (range, 0-6). All feet had a residual cavovarus both clinically and on the radiographs.

Conclusion: Patient satisfaction and clinical outcome was shown to improve pre- to postsurgery at intermediate follow-up after peroneus longus to brevis transfer and metatarsal osteotomies with or without additional calcaneal osteotomies as part of a cavovarus foot correction.

Level of Evidence: Level IV, case series.

Keywords: cavovarus foot, peroneal tendons, peroneus longus, peroneus brevis, dorsal bunion

Introduction

Several studies have reported on the association between peroneus brevis and/or peroneus longus tendon tears in patients presenting with a cavovarus foot.^{1,5,23} Mosca suggested that a weakness of the peroneus brevis in combination with a functioning peroneus longus could cause the hindfoot varus condition.¹⁹ He argued that the plantarflexed first metatarsal results from hyperactivity of the peroneus longus muscle without the peroneus brevis abducting the foot. Coleman coined the term “forefoot driven hindfoot varus” to describe this condition, introducing a test evaluating if the plantarflexed first ray forces the hindfoot into varus (Coleman blocktest).⁴ Planning operative treatment of the cavovarus foot is typically addressed with an osteotomy of the first metatarsal when considering the “forefoot driven hindfoot varus.”⁸ The present patient study aims to describe changes in patient satisfaction and foot function resulting

from cavovarus foot surgery including a combination of osteotomy of the first metatarsal, peroneus longus to brevis transfer, and ligament reconstruction in patients without any neurologic condition. The operative method is based on the preoperative result of Coleman blocktest. We hypothesized that patient satisfaction would improve, despite the loss of the peroneus longus function. No previous clinical follow-up study has presented the outcome of a metatarsal osteotomy in conjunction with peroneus tendon transfer in operative

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treatment of the cavovarus foot in patients without a history of neurologic symptoms.

Material and Methods

Between June 1, 2004, and December 31, 2010, a total of 167 patients (170 feet) underwent surgery for peroneal tendon pathology at our institution. The peroneal tendon pathology was verified preoperatively by MRI. The different types of operative procedures were as follows: suture of peroneal tear in conjunction with a Broström lateral ligament repair (104 patients, 104 feet), primary surgery of peroneal tendons with either repair or synovectomy (30 patients, 31 feet), surgery for subluxation of peroneus brevis (11 patients, 11 feet), and finally, 22 patients (24 feet) had clinically such severe varus deformity that osteotomies were performed during surgery, either a dorsiflexion osteotomy of the first metatarsal or a sliding lateralizing osteotomy of the calcaneus, or both. These 22 patients with osteotomies were eligible for this longitudinal study with at least 2 years of follow-up.

All operations had been performed by the senior author, and the follow-up was done independently by the first author.

Possible neurologic conditions before surgery were identified by the surgeon and 10 patients were additionally examined by a neurologist. In order to make the study group less heterogeneous, we excluded patients with a confirmed neurologic diagnosis. In our follow-up, we subsequently excluded 4 patients due to neurologic conditions (2 with Charcot-Marie-Tooth and 2 with sciatica), and 1 patient with congenital talipes equinovarus. One patient had moved away from the area and could not be traced for a follow-up. One patient had undergone surgery on both feet, but he could not attend the radiographic examination of his second foot, being abroad, so this second foot was excluded. This left 16 patients (17 feet) who were included in the present study. The median time to follow-up was 39 (range, 24-72) months.

Demographic data of our study group, consisting of the age, gender, and the type of surgery, are presented in Table 1. There were 11 men and 5 women, and mean age at surgery was 45 years, with a median of 47 years (range, 16-67). One patient also underwent surgery for non-union of a fracture at the base of the fifth metatarsal. All but 2 patients had a modified Broström lateral ankle ligament reconstruction performed simultaneously. One patient had undergone previous surgery with peroneus longus to brevis transfer in combination with a modified Broström ligament reconstruction, but after a year he required a reoperation with osteotomy of the first metatarsal and a calcaneal shift. Because the patient after the combination of the 2 operations met the inclusion criteria in this study, we decided to include this person in the cohort. There were no wound healing problems in any of the patients. Fifteen patients had peroneus brevis pathology, 6 of them in combination with peroneus longus pathology, whereas 2 had isolated peroneus longus

pathology. Although the preoperative MRI showed pathology in the peroneal tendons in all patients, the reports were not always accurate as to which tendon was affected (Table 1).

All patients had long-standing symptoms of lateral ankle pain preceding the time of referral, ranging from 6 months to 10 years. Eight patients had experienced a previous supination injury of the ankle, and 8 patients could not recall any specific injury. Weakness of eversion of the foot at the preoperative examination was noted in 9 patients to be of grade 4/5 on the Medical Research Council (MRC) Scale for Muscle Strength, and 1 patient had weakness grade 3/5. All but 2 patients had ligamentous laxity of the ankle as shown by the anterior drawer test. The drawer test was performed during clinical assessment and then confirmed on the day of surgery with the patient under general anesthesia. We did not have the opportunity to perform stress radiographs. All patients presented with a swelling and pain behind the lateral malleolus as well as a varus hindfoot.

The follow-up included patient-reported visual analog scale (VAS) for pain and the American Orthopaedic Foot & Ankle Society (AOFAS) hindfoot score, a clinical examination, and weightbearing radiographs of the foot and ankle. The AOFAS hindfoot score is a clinician-reported and patient-reported score, with a total of 100 points for a healthy foot.¹² In 15 patients, the AOFAS hindfoot score had been noted preoperatively. On the postoperative weightbearing radiographs, the lateral talo-first metatarsal angle was measured (Meary angle),¹⁸ as well as the calcaneal inclination angle (calcaneal pitch).²⁸ These 2 measurements indicate the severity of the cavus foot (Figure 1). The talocalcaneal angle on the anteroposterior view (Kite angle)²⁸ and the tibio-calcaneal alignment using the Saltzman view²⁴ was measured as an indication of the varus hindfoot severity (Figures 2 and 3). The Saltzman view, described by Saltzman and El-Khoury in 1995, is a weightbearing view including the calcaneus and the tibia. The distance between the long axis of the tibia and the axis of the calcaneus is measured on the radiographs. In a normal foot, the weightbearing line of the tibia falls within 8 mm of the lowest calcaneal point in 80% of subjects. The preoperative radiographs could not be obtained, because they had been given to the patients and not saved at the radiology department. Almost all patients had lost their previous radiographs. The radiology reports were, however, saved in the files, reporting normal feet, except for patient number 10, who had osteoarthritis in the ankle.

Operative Technique

Based on the findings of Coleman block test,⁴ a dorsal closing wedge osteotomy to the first metatarsal was first performed with a separate dorsal incision. The osteotomy was secured using a small plate with 4 screws. The decision as to how large a wedge to remove was based on the intraoperative examination, palpating the plantar aspect of the foot

Table 1. Demographic Data of Patients Included in the Study.

Patient	Gender	Age at Surgery	Side	Type of Surgery for Peroneus Tendon and Varus Hindfoot	Additional Procedures	Tendon Affected at Surgery	Tendon Affected on MRI
1	M	48	R	Calc shift, Broström, PL to PB transfer		PB+PL	PB+PL
2a	M	53	L	Osteotomy first MT, Broström, PL to PB transfer		PB+PL	PB+PL
2b	M	56	R	Osteotomy first MT, calc shift, Broström, PL to PB transfer		PB	PB
3	M	59	L	Osteotomy first MT, calc shift, Broström, PL to PB transfer		PB	PB
4	M	19	L	Osteotomy first MT, Broström, PL to PB transfer	Ankle arthroscopy	PB	Tenosynovitis
5	M	16	L	Osteotomy first MT, calc shift, Broström, PL to PB transfer	Jones fracture	PL	Tenosynovitis
6	M	26	L	Osteotomy first MT, calc shift, Broström, PL to PB transfer	Ankle arthroscopy	PB	Tenosynovitis
7	M	47	R	Osteotomy first MT, Broström, PL to PB transfer		PB+PL	PB
8	F	44	L	Osteotomy first MT, calc shift, Broström, PL to PB transfer	Anterior tibia osteotomy	PB	PB
9	F	67	L	Osteotomy first MT, Broström, PL to PB transfer		PL	Tenosynovitis
10	M	42	R	Osteotomy first MT, Broström, PL to PB transfer		PB	PB
11	M	55	L	Osteotomy first MT, Broström, PL to PB transfer		PB+PL	PB+PL
12	F	57	L	Osteotomy first MT, PL to PB transfer		PB	PB
13	M	32	R	Osteotomy first MT, PL to PB transfer		PB+PL	PB
14	F	55	R	Osteotomy first MT, Broström, PL to PB transfer,	2+3 Weil and PIP-fusion, Jones procedure	PB	PL
15	M	47	R	Osteotomy first MT, Broström, PL to PB transfer		PB+PL	PB
16	F	38	L	Osteotomy first MT, Broström, PL to PB transfer		PB	PL

Abbreviations: F, female; L, left; M, male; MT, metatarsal; PB, peroneus brevis; PIP, proximal interphalangeal; PL, peroneus longus; R, right.

and comparing the pressure of the lesser metatarsal heads. The lateral 4 rays were held with one hand, and the first ray was then pushed up to be parallel with the second ray. Following this, the calcaneal sliding osteotomy was performed, if considered necessary, through a separate lateral incision. The osteotomy was secured using a 7.3-mm cancellous screw as fixation.

A curvilinear longitudinal incision was then made over the distal fibula. The superior retinaculum and distal tendon sheath were opened and the peroneal tendons explored. Care was taken to identify and protect the sural nerve in the operative incision. A peroneal tenosynovectomy was then performed and the peroneal tubercle was excised with a bone rongeur. Following the advice of Krause and Brodsky,¹⁰ if extensive damage (a tear leaving less than 50% of the cross-sectional area of the peroneus brevis tendon) was found, a peroneus longus to distal brevis transfer was performed. The peroneus brevis tendon was transected 4 cm proximal to the site of proposed anastomosis and the

degenerated portion of the tendon completely excised. The peroneus longus tendon was then transected in the cuboid tunnel (usually immediately proximal to the os peroneum). After this the peroneus longus tendon was tagged with a no. 1 Vicryl suture using a Krakow technique, and the tendon was initially sutured to the distal peroneus brevis tendon with a grasping suture using eyed Mayo round-body needles. Once the ends of the no. 1 Vicryl suture had been passed through the distal peroneus brevis tendon, the ankle was manually moved in a plantigrade and maximal eversion position, which set the appropriate tension in the tendon transfer before tying the tagging suture. A further 3-cm section of the distal peroneus brevis was sutured to the distal 3 cm of the peroneus longus tendon in a side-to-side fashion using interrupted no. 0 PDS sutures. If the peroneus brevis muscle was not fibrotic, the proximal peroneus brevis tendon was sutured to the peroneus longus tendon above the ankle, but if the peroneus brevis muscle was inelastic and fibrotic, a proximal tenodesis was not performed. If the peroneus

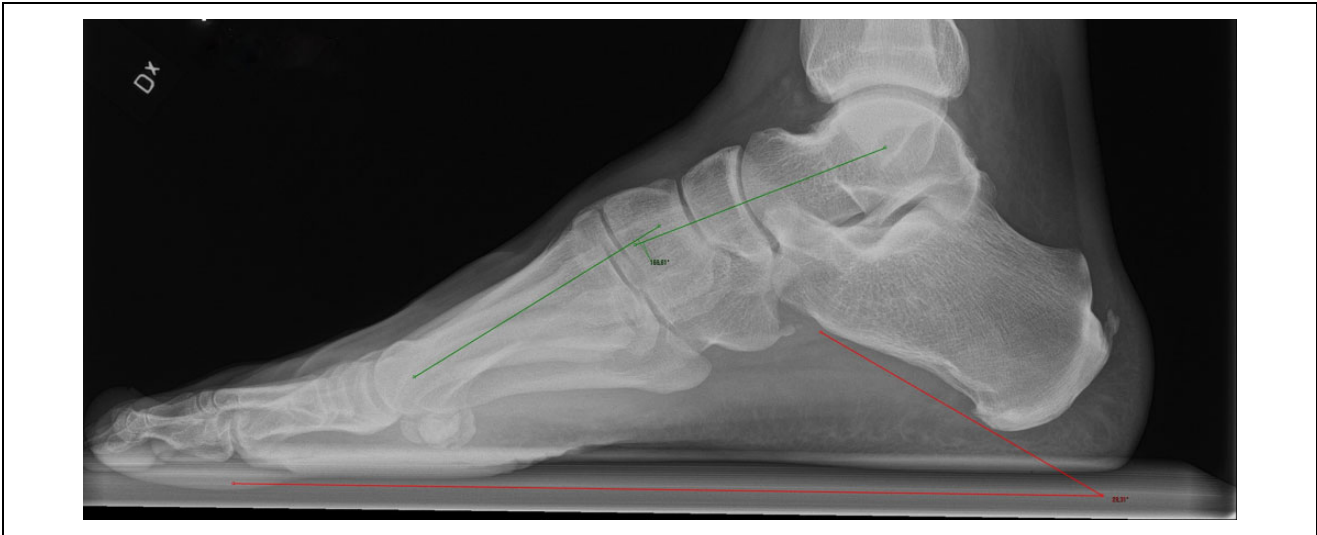


Figure 1. Lateral view of a cavovarus foot with measurements, Meary line, and calcaneal inclination angle.



Figure 2. Anterior-posterior view of a cavovarus foot with measurements, kite angle.

longus was damaged, the tendon was sutured proximally to the brevis tendon with side-to-side sutures, and the distal damaged part excised. In all the patients at least 1 of the tendons were repairable. The superior peroneal retinaculum was then reconstructed with intraosseous no. 0 Vicryl sutures. If examination under anesthesia with the drawer test showed pathologic ankle laxity, a modified Broström procedure (based on the studies by Gould and Karlsson)^{2,7,9} was



Figure 3. Saltzman view of a cavovarus foot.

performed. If an osteochondral lesion of the talus was observed on the preoperative MRI, an ankle arthroscopy was performed at the start of the operation with debriding and microfracture of the lesion.

The postoperative regimen was nonweightbearing posterior splint for 2 weeks and a partial weightbearing fiber-glass cast for additional 4 weeks (nonweightbearing for 4 weeks if a calcaneal osteotomy had been performed), followed by 2 weeks in a controlled ankle motion (CAM) boot. The foot was then put in a stirrup brace for up to 3 months postoperatively. Physiotherapy started at 6 weeks, when the patients came out of the cast.

Statistical Analysis

The sample in this study is small, but a statistical analysis was performed on the AOFAS scores. Both pre- and postoperative scores were normally distributed (Shapiro-Wilk test $W > 0.95$). We estimated average changes in AOFAS scores by a paired t test. Two missing values of the score at baseline were replaced with the mean of the preoperative group. In a sensitivity analysis, a complete case analysis was performed.

Results

The clinical data from the follow-up are presented in group level in Table 2. Fifteen patients (15 feet) who had AOFAS hindfoot score recorded preoperatively had a mean score of 57 (range, 36-76; SD 11) points. At the follow-up in 2010-2012, the mean AOFAS hindfoot score (including all 17 feet) was 82 (range, 58-100; SD 11) (Figure 4). The average score improvement was 25 (95% confidence interval 16-35; $P < .0001$). Similar results were obtained by a complete case analysis, with an average score improvement of 24 ($P = .0003$). The pain at walking on the visual analog scale (VAS) was postoperatively noted to be mean 2 (range, 0-6), where 10 is worst possible pain and 0 is no pain (Table 2). Three patients had noted Achilles tendon tightness, and one of them had tendinosis in the Achilles tendon. In 3 patients locking symptoms were experienced. One patient had had the screws and plate in the first metatarsal removed. Three patients could feel the plate over the first metatarsal wearing tight shoes, but they were not interested in a plate removal. None of the patients had developed a "dorsal bunion" of the first ray.¹⁵ Eleven patients (12 feet) used custom-made ethylene vinyl acetate (EVA) orthotics.

At the final clinical examination, 4 patients had a slight pain posterior to the lateral malleolus and 5 still had numbness of the sural nerve over the lateral aspect of the foot, although no symptomatic neuromas could be found. Observing the standing patient from the front, the "peek-a-boo heel" sign could be observed in all patients on the operated foot, indicating a subtle residual hindfoot varus.^{15,16} Three patients had clinically a more severe hindfoot varus, stated by the examiner as "obvious." Thirteen of the 16 patients

were noted to have idiopathic bilateral cavovarus feet (Figure 5) and the other 3 had a neutral hindfoot on the contralateral side. There were no planovalgus feet on the contralateral side. The pattern of callosities on the plantar aspect of the operated foot showed a normal distribution in 9 feet, a slight overweight of the fifth metatarsal head in 7 feet, and 1 foot had a severe callosity of the fifth metatarsal head. In 16 feet, no weakness in plantar flexion of the first metatarsal could be found during clinical examination compared with the nonoperated foot when the patient was pushing down on the examiner's hand. In 1 foot, there was a slight weakness in plantar pressure of the first metatarsal (4/5 on the MRC Scale for Muscle Strength). Two patients had a slight weakness in eversion (4/5 on the MRC Scale for Muscle Strength). In 11 of 17 feet, a positive anterior drawer test was found on examination, but only 4 patients reported instability. None of the patients had generalized joint hypermobility.

Radiographs at follow-up showed in general a residual cavus foot (Table 3). One patient (number 10) had osteoarthritis of the ankle joint. The Saltzman view was used in 14 feet (13 patients), and 2 of these could be considered a normally aligned hindfoot, the other 12 feet had a residual varus hindfoot.

Discussion

This study's most important finding is that the patients were satisfied after cavovarus foot surgery with osteotomy and peroneus longus transfer. More negative effect on foot function with the loss of peroneus longus might have been expected, but with the exception of 1 patient, no weakness in push-off was observed at examination, and only 2 patients displayed weakness in eversion after the peroneus longus to brevis transfer. In examining the weakness in push-off, the same technique as in the preoperative examination was used, but the use of a pedobarography system might have been more precise.

None of the patients in the present study developed a dorsal bunion of the first metatarsal, despite the peroneus longus being resected in the cuboid tunnel. Thompson and Patterson also noted that a dorsal bunion did not develop in their report of 3 patients with peroneus longus rupture,²⁹ although Manoli and Graham described a peroneus longus to brevis transfer as part of the cavovarus foot surgery and mentioned that the distal part of peroneus longus should be sutured to the peroneus brevis because "this avoids the formation of a dorsal bunion."¹⁵ The dorsal bunion deformity consists of the elevation of the first metatarsal head, and this term was first used by Lapidus in 1940,¹¹ where he mentions 3 types of imbalance in the muscles around the ankle in "paralytic deformities of the foot," one of them being a weak peroneus longus with strong tibialis anterior and flexor hallucis longus muscles. He also described the dorsal bunion in different conditions in children. In recent literature, the dorsal bunion is mentioned in adolescents or adults who have

Table 2. Clinical Findings Pre- and Postoperative, Group-Level Data.

Follow-up (mo)	Mean (SD)	Pain Over Peroneal Tendons Postoperative, n		Hindfoot Varus Postoperative, n		VAS Postoperative, Mean (Range)		AOFAS Hindfoot Score Postoperative, Mean (SD)		Difference in AOFAS, Mean (95% CI)			
		n	4	n	17	n	17	82 (11)	57 (11)		25 (16 to 35)		
42 (13)													
Patient	Time Surgery-Follow-up (mo)	Pain Over Peroneal Tendons Postoperative		Hindfoot Varus Postoperative		Hindfoot Varus Postoperative		Custom-Made Insoles		VAS Postoperative	AOFAS Hindfoot Score Preoperative	AOFAS Hindfoot Score Postoperative	Difference in AOFAS
		Preoperative	Postoperative	Preoperative	Postoperative	Preoperative	Postoperative	Callosity	Callosity				
1	72	Yes	No	Yes, right side	Yes, obvious	Yes	Base and head of 5th MT	0	50	90	40		
2a	61	Yes	Yes, slight	Yes, bilateral	Yes, obvious	Yes	Normal distribution	3 (walking)	58	72	14		
2b	34	Yes	Yes, slight	Yes, bilateral	Yes, slight	Yes	Severe at base of 5th MT	5-6 (walking) pain at base of 5th MT	58	58	0		
3	42	Yes	No	Yes	Yes, slight	Yes	Normal, but less on MTP 1	2-3 (walking)	51	82	31		
4	37	Yes	No	Yes	Yes, slight	Yes	Normal, but more prominent on forefoot	0	-	97	-		
5	29	Yes	No	Yes, bilateral	Yes, slight	Yes	Normal	0	49	100	51		
6	25	Yes	Yes, slight	Yes	Yes, slight	Yes	Normal but a bit more on forefoot	0-4 (walking, pain from ankle)	53	82	29		
7	48	Yes, and ankle	No	Yes	Yes, slight	Yes	On 5th MT	1 (running)	-	95	-		
8	57	Yes	No, but pain over ankle	Yes	Yes	No	More on MTP 2 and 5	4 (walking in shoes)	76	76	0		
9	57	Yes, and ankle	No	Yes, slight	Yes, slight	No	Slightly more on 5th MT	0	57	92	35		
10	45	Yes	No	Yes, bilateral	Yes, obvious	Yes	Slightly more on 5th MT	0	72	74	2		
11	44	Yes	No	Yes, bilateral, worse left side	Yes, slight	No	More on forefoot MTP 2+3	0	40	74	34		
12	39	Yes	Yes, around lat mall	Yes, slight	Yes, slight	No	Slightly more on 5th MT	6 (walking)	67	68	1		
13	36	Yes	No	Yes, bilateral	Yes, slight	Yes	Slightly more on 5th MT	1	61	94	33		
14	31	Yes	No	Yes	Yes, slight	No	More on 5th MT	2-5 (walking)	60	64	4		
15	33	Yes	No	Yes, bilateral, worse right side	Yes, slight	Yes	Normal	0	36	93	57		
16	24	Yes	No	Yes, worse left side	Yes, slight	Yes	Normal	0	70	97	27		

Abbreviations: AOFAS, American Orthopaedic Foot & Ankle Society; CI, confidence interval; MT, metatarsal; MTP, metatarsophalangeal; VAS, visual analog scale.

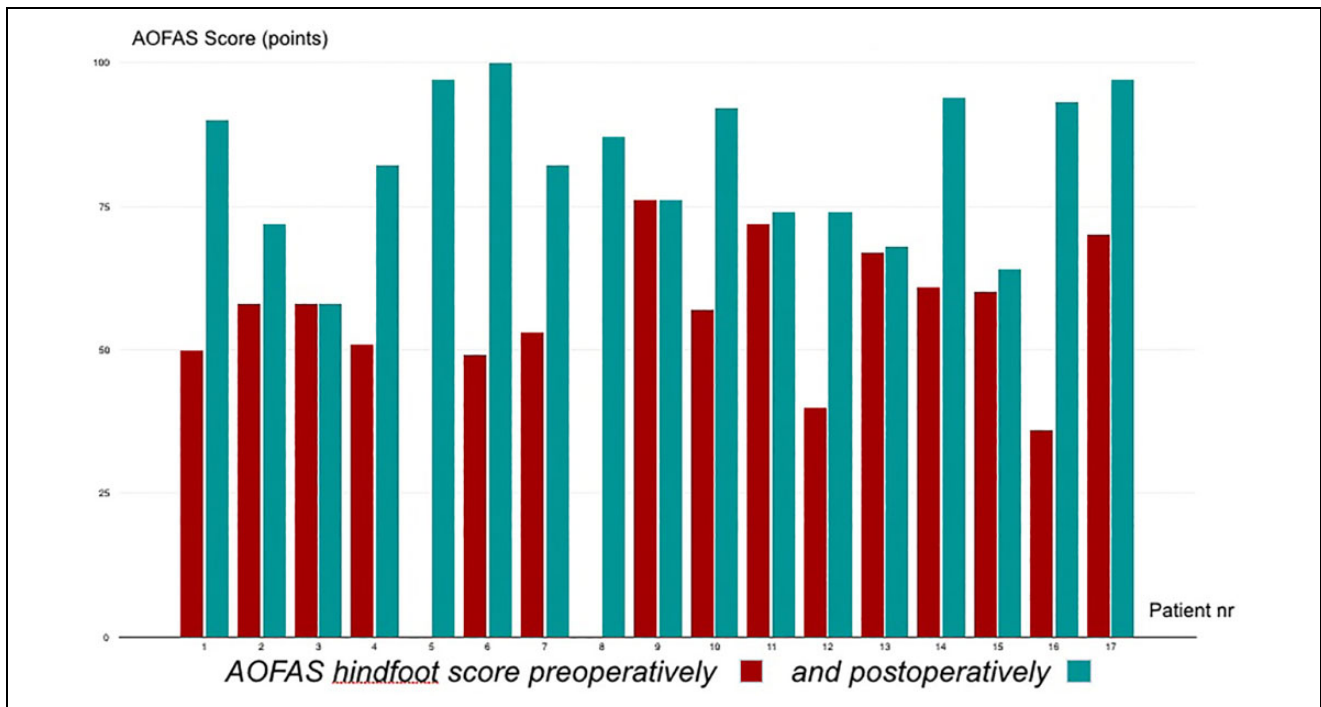


Figure 4. Pre- and postoperative AOFAS hindfoot scores.



Figure 5. Patient 6 at follow-up. Bilateral cavovarus feet, surgery performed on the left foot.

undergone club foot surgery as a child,^{22,32} and the cause of the deformity is attributed to weakness of the Achilles tendon, overpowering of flexor hallucis longus and strong tibialis anterior tendon with weakness of the peroneus longus. This type of foot has a much more complex pathology than only a peroneus longus dysfunction. Not a single study has been found that supports the development of a dorsal bunion in the case of peroneus longus rupture in the adult foot.

Strengths of the present study are the first postoperative longitudinal clinical evaluation of this patient category with a structured follow-up of at least 2 years, few patients lost to

follow-up, 1 surgeon with long-term experience in foot surgery, and an independent observer that performed the clinical evaluation of the patients. Although the study group is small, this group represents a specific subset of patients presenting with a peroneal tendon tear. This study is a step toward a universal approach to the assessment and operative treatment of this patient group. The main limitation is the loss of the preoperative radiographs, and thus we can only conclude that all patients postoperatively still had a cavovarus foot. Because one of the aims in cavovarus surgery is to re-create a plantigrade foot,¹⁵ it might be advisable to correct the varus hindfoot even more, for example with a more constant use of a calcaneal osteotomy. The patient cohort is limited, making it difficult to draw any firm conclusions from the 6 cases who underwent calcaneal osteotomy compared with the 11 feet with only metatarsal osteotomy in terms of satisfaction or correction; however a trend toward better correction of the deformity in the patients who underwent calcaneal osteotomy is evident. The use of Coleman block test was not reliable in the preoperative planning as a deciding factor whether to address only the forefoot or include the hindfoot in the surgery. The procedure of osteotomy of the first metatarsal in combination with peroneus longus to brevis tendon transfer, as suggested by Kaplan, requires a flexible foot—but the cavovarus foot in the adult is rigid and the surgeon should probably have a low threshold for undertaking additional corrective osteotomies, such as the sliding calcaneal osteotomy.⁸ The majority of patients in the current study had subtle cavovarus feet, and as noted by Maskil et al,¹⁷ this condition seems to be mainly

Table 3. Measurements From Postoperative Radiographs.

Patient	Lateral Talometatarsal Angle, degrees (>5 degrees = Cavus Foot)	Calcaneal Inclination Angle, degrees (>30 degrees = Cavus Foot)	Talocalcaneal Angle, degrees (<21 degrees = Varus Hindfoot)	Saltzman View, mm (>3 mm = Varus Hindfoot)
	Postoperative	Postoperative	Postoperative	Postoperative
1	11	30	24	4
2a	10	23	28	3
2b	2	20	26	4
3	20	34	30	4
4	3	30	22	5
5	5	35	14	Incorrectly taken
6	7	26	20	5
7	8	27	16	6
8	10	20	22	7
9	10	22	17	6
10	21	32	17	10
11	17	38	18	Incorrectly taken
12	6	28	9	7
13	13	36	15	2
14	9	14	28	7
15	8	25	20	Not taken
16	14	25	21	6

hindfoot driven. We observe that the use of Coleman block test to determine which patients avoided a lateral shift calcaneal osteotomy did not result in a normal valgus alignment following surgery.

The effects of different types of calcaneal osteotomy have recently been studied *in vitro*,^{3,22} revealing a limit on how much the varus hindfoot can be corrected using the sliding osteotomy. The surgeon must also consider the risk of entrapment of the tibial nerve, which limits the lateral heel shift.²⁷ One could consider the use of the scarf osteotomy of the calcaneus in order to better align the hindfoot,¹³ or the modified Dwyer osteotomy.²² On the other hand, in the present study there were no differences in the AOFAS score between the patients with or without calcaneal osteotomy. Redfern and Myerson showed similar results, reporting operative treatment of 29 cavovarus feet,²³ where they found a slight residual varus hindfoot in 9 feet treated with calcaneal closing wedge biplanar osteotomies, but no difference in outcome between these patients and the remaining 19 operated on with only tenodesis. Possibly the surgeon does not need to correct the cavovarus foot completely to a plantigrade foot, but the patient's acceptance of residual varus is at present unclear.³⁰ Moreover, we are concerned about the natural history of residual hindfoot varus, because this might lead to stress on the lateral structures and a recurrence of the instability.²⁰

The typical patient who develops a hindfoot varus with peroneal tendon pathology in our study appeared to have bilateral subtle cavovarus feet with no recollection of a specific injury, but with repetitive overload of the lateral structures of the foot. They have a degenerative rupture of the peroneus brevis with or without a peroneus longus tear. High

numbers of peroneus brevis and longus tears^{5,22} and peroneus longus tears¹ have been reported in patients with bilateral cavovarus feet, because the tendons are put under stress. A person with a familiar form of cavovarus foot (the so called "subtle cavovarus foot")¹⁵ will have the risk of tears to the peroneal tendons ending with an acquired varus hindfoot. This can be compared with the flat foot, where a congenital low arch attracts a higher risk of the tibialis posterior tendon pathology and a subsequent acquired flat foot.¹⁴ Lateral ligament injuries with resulting laxity is another risk factor for injury to the peroneal tendons.^{6,25} This is also supported by the results of the present study, with 15 of 17 feet showing lateral instability. In addition, it has been shown that patients with cavovarus feet have a higher risk of lateral ligament injuries during sports activities.³¹ There appears to be an "unhappy triad," that is, cavovarus feet leading to ligament instability and peroneal tendon injuries—but also peroneal tendon injuries and ligament instability worsening the cavovarus foot position.

Clinical Relevance

We report the results of cavovarus foot surgery on 1 type of patient, without any neurologic deficiencies, but with injured peroneal tendons and lateral ligaments. The surgery included a peroneus longus to brevis tendon transfer and osteotomy of the first metatarsal or calcaneus based on the outcome of Coleman block test. It is often stated that the surgery for the cavovarus foot has to be individualized, based on different patient individual factors, including the neurologic background and the flexibility or rigidity of the joints.^{8,15,21} An algorithm is needed to help the surgeon to choose the correct

procedures, but an accurate individualized surgery selection decision tree is not clearly defined at present, even if there are suggestions in observational studies.^{17,26} Because treatment of the cavovarus foot includes many different procedures it is difficult to know which one of them has the most significant effect on patient satisfaction. It is possible that another procedure can achieve similar results to the ones reported here, but a comparative study would be needed. Regardless, the 17 feet reported here provide us with useful insights and identify several avenues for future work.

Conclusion

Patients with cavovarus feet have good results after osteotomy of the first metatarsal bone in combination with a peroneus longus transfer and suture of the lateral ligaments. We therefore recommend the peroneus longus to brevis transfer in the cavovarus foot surgery. We also advocate the more proactive approach using calcaneal osteotomy, which we suggest might even further improve the alignment of the foot.

Ethics Approval

Ethical approval for this study was obtained from the Epworth HealthCare Human Research Ethics Committee and by the National Health and Medical Research Council in Australia.

Declaration of Conflicting Interests

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