Original Article With Video Illustration

Arthroscopic Talocalcaneal Coalition Resection in Children

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Purpose: To present the technique and outcomes of arthroscopic talocalcaneal coalition (TCC) resection in pediatric patients. **Methods:** We performed a prospective study of 16 consecutive feet with persistent symptomatic TCCs in 15 children. The mean age was 11.8 years (range, 8 to 15 years), and the mean follow-up period was 28 months (range, 12 to 44 months). A posterior arthroscopic TCC resection was performed. The plantar footprint, subtalar motion, pain, and the American Orthopaedic Foot & Ankle Society Ankle-Hindfoot scale score were evaluated preoperatively and postoperatively. Preoperative computed tomography (CT) scans were used to classify the coalition according to the Rozansky classification, to measure the percentage of involvement of the surface area, and to determine the degree of hindfoot valgus. Postoperative CT scans at 1 year (n = 15) and 3 years (n = 5) were used to assess recurrences. Patient satisfaction was also evaluated. **Results:** The TCC distribution according to the Rozansky classification was type I in 7 cases, type II in 3, type III in 3, and type IV in 3. In all cases the arthroscopic approach enabled complete coalition resection. All patients increased by at least 1 stage in the footprint classification and showed clinical subtalar mobility after surgery. All patients showed a statistically significant improvement in pain after surgery except for 1 patient in whom complex regional pain syndrome developed ($P < .001$). The mean American Orthopaedic Foot & Ankle Society score was 56.8 (range, 45 to 62) preoperatively versus 90.9 (range, 36 to 100) postoperatively, showing a statistically significant increase ($P < .001$). Preoperative CT scans showed that all TCCs involved the medial subtalar joint facet, with mean involvement of 40.8% of the articular surface. All postoperative CT scans showed complete synostosis resections with no recurrences at final follow-up. At final follow-up, all patients were either satisfied (n = 4 [27%]) or extremely satisfied (n = 10 [67%]) with the outcome, except the 1 patient (7%) in whom complex regional pain syndrome developed. **Conclusions:** Arthroscopic TCC resection provides good outcomes (symptom relief and restoration of subtalar motion), with no recurrence of the coalition. **Level of Evidence:** Level IV, therapeutic case series.

Talocalcaneal coalition (TCC) is a common congenital disorder that typically becomes symptomatic in the early teenage years. TCC causes gradual flattening of the longitudinal arch and stiffness of the subtalar joint.[1,2] Apart from hindfoot stiffness, excessive hindfoot valgus deformity can be an important source of symptoms in these patients.[2,3]

Surgery is generally indicated when nonoperative management fails to relieve pain.[2] Although satisfactory long-term outcomes have been reported after coalition resection with the classic open surgical approach, such is not without complications.[3] Furthermore, the medial incision does not allow adequate visualization of the posterior subtalar facet.[4] Since 2010, largely driven by the impression that a less invasive technique might lead to improved esthetics, less morbidity, and a decreased hospital stay and recovery, we have adopted a minimally invasive arthroscopic approach to correct symptomatic TCCs in the pediatric population. We combined our technique with the calcaneo-stop procedure in patients with severe hindfoot valgus deformity.[3]

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The purpose of this article was to present the technique and outcomes of arthroscopic TCC resection in pediatric patients. Our hypothesis was that arthroscopic TCC resection would be safe and effective (yielding pain relief and subtalar joint motion restoration).

Methods

After the implementation of arthroscopic TCC resection in our hospital in 2010, a prospective data register was designed for the evaluation of its results. Our institutional review board approved this prospective study.

Patients who received a TCC diagnosis at our institution were identified in the prospective data register. The inclusion criterion for surgery was a persistent symptomatic TCC (failure of conservative treatment for ≥6 months). The exclusion criteria were a coalition involving more than 50% of the subtalar joint and the presence of joint degenerative changes. Patients presenting with severe hindfoot valgus deformity (>20°) also underwent the calcaneo-stop procedure.[3,5]

Besides patient demographic information, we measured subtalar motion (calcaneus varization after the tiptoe standing test, as well as dorsal and plantar foot flexion) preoperatively and postoperatively. We also performed computed tomography (CT) scans of the hindfoot before surgery and 1 and 3 years after surgery. The preoperative and postoperative assessment and surgical treatment of all patients were performed by one of the authors (J.K.). Patient-rated instruments including the American Orthopaedic Foot & Ankle Society (AOFAS) Ankle-Hindfoot scale[6,7] (minimum score of 0 and maximum score of 100; rated as excellent, 90 to 100; good, 80 to 89; fair, 70 to 79; or poor, <70) and an ordinal 3-point Likert scale for treatment satisfaction (not satisfied, 0; satisfied, 1; and extremely satisfied, 2), were administered. Preoperative and postoperative pain intensity was assessed with the AOFAS numeric scale. The presence and staging of flatfoot were assessed with the Johnson and Strom classification.[8]

Preoperative CT scans were used to classify the coalition according to the Rozansky classification (type I, linear coalition; type II, linear coalition with posterior hook; type III, shingled coalition; type IV, complete bony coalition; and type V, small peripheral posterior bony coalition)[9]; to measure the percentage of involvement of the surface area according to the technique of Comfort and Johnson[10]; and to determine the degree of hindfoot valgus using the technique described by Wilde et al.[11] Intraoperative and postoperative surgical complications were also recorded.

Arthroscopic Surgical Technique

The patient was placed in the supine position, and a tourniquet was placed at the level of the leg, 10 cm distal to the fibular head (Video 1, available at www.arthroscopyjournal.org). The involved foot was placed 10 cm distal to the border of the operating table with the leg over a cushion. The contralateral leg was inclined downward to avoid imaging interposition while fluoroscopy was performed during the procedure. A C-arm fluoroscope was used to obtain profile images. The arthroscopic monitor was positioned opposite to the fluoroscopic screen (Fig 1).

A 2-portal hindfoot endoscopy approach, as originally described by van Dijk,[12,13] was performed in all patients. The portals were located on both sides of the Achilles tendon. Only patients undergoing the calcaneo-stop procedure were administered prophylactic antibiotics.

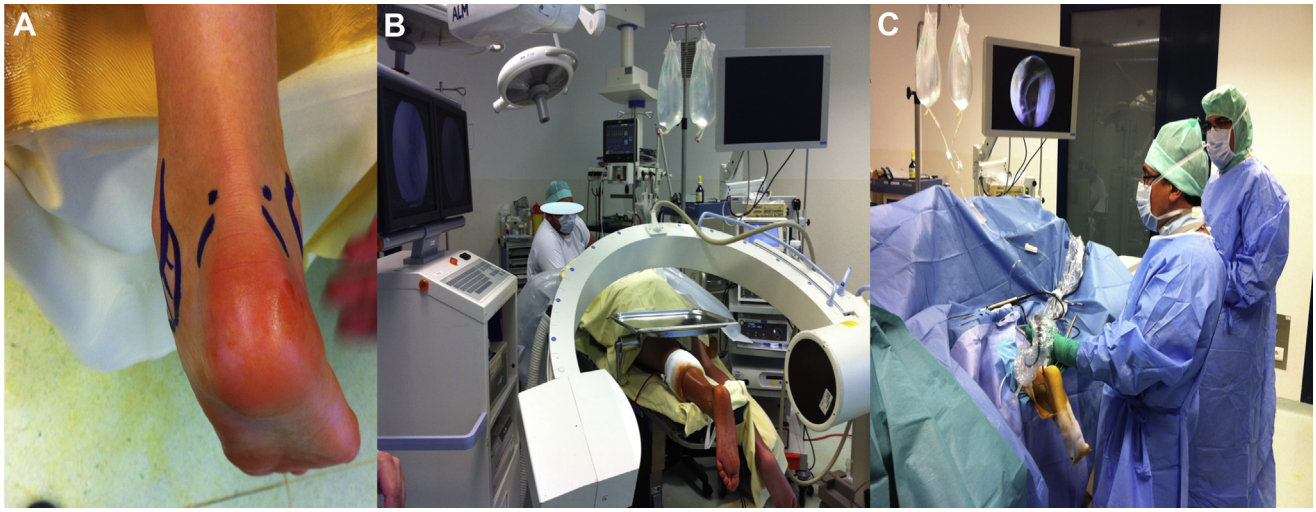

Fig 1. (A) The patient is placed in the supine decubitus position with the involved (left) foot placed over a bolster. Two portals, one medial and one lateral to the Achilles tendon, are placed. (B) An image intensifier is used during the procedure to obtain profile images. (C) The arthroscopy monitor is positioned opposite to the fluoroscopic screen.

After the posterior talocalcaneal joint was visualized, the flexor hallucis longus (FHL) tendon was identified (Fig 2 A and B) and isolated from its tendon sheath (Fig 2C). Following, distally, the posterior talocalcaneal joint line and the FHL tendon, the surgeon localized the coalition (Fig 2D). An arthroscopic working chamber was established lateral to the FHL tendon; this helped protect the tibial neurovascular bundle, which was located medial to the tendon. The FHL tendon was separated with a textile band.

The surgeon resected the coalition with a motorized burr facing laterally (Fig 2E). The burring was performed without aspiration to avoid injuring the medial soft tissue and neurovascular bundle. Initially, the resection technique consisted of creating a tunnel within the coalition to preserve a medial bone shell that would also help preserve the medial soft tissue and neurovascular structures. Then, the remainder of the medial bone shell was removed with a Smillie Meniscus Knife (V. Mueller, Berlin, Germany) (Fig 2F). For later cases, the coalition was primarily burred without the need for creation of a tunnel and a bone shell (Video 1, available at www.arthroscopyjournal.org). The coalition resection measured approximately 15 mm vertically and proceeded laterally until the talocalcaneal articular line was reached. Talocalcaneal joint motion was subsequently assessed by performing varus-valgus calcaneus movements (Fig 2 G and H). The arthroscopy portals were closed with resorbable sutures. Early postoperative active and passive foot and ankle mobilization was initiated, followed by gradual resumption of weight-bearing activities as tolerated by pain, under the supervision of a physical therapist.

Calcaneo-Stop Technique

For the calcaneo-stop technique,[3,5] a 10-mm incision was performed at the level of the sinus tarsi. The calcaneus was kept in the varus position during the procedure. A 6.5-mm spongious screw was inserted, after drilling with a 4-mm drill bit under fluoroscopic guidance. The screw was inclined 25° in relation to the frontal and sagittal planes. The goal was to prevent eversion at the level of the subtalar joint by impingement of the screw head in the lateral apophysis of the talus (Fig 3).

Statistical Analysis

The Shapiro-Wilk test indicated that only a few parameters were not normally distributed, so we decided to use parametric tests for all data. Paired *t* tests were performed to compare preoperative and postoperative changes. $P < .05$ was deemed statistically significant in all analyses. We used SPSS software (version 22.0; SPSS, Chicago, IL) for all statistical analyses.

Results

Between April 2010 and December 2012, a total of 21 children with TCCs presented to our institution. Of these patients, 4 had symptom improvement with conservative management and 2 refused operative treatment. Thus, the final study cohort consisted of 16 feet with persistent symptomatic TCCs in 15 children. There were 10 male and 5 female patients (Table 1). The mean age at the time of surgery was 11.8 years (range, 8 to 15 years). We set the minimum length of follow-up at 12 months. Four patients had a hindfoot valgus deformity greater than 20° and thus also underwent the calcaneo-stop procedure.

The mean follow-up period was 28 months (range, 12 to 44 months). Preoperatively, all patients (100%) complained of mechanical pain and difficulty performing sporting activities and walking for long distances. Repetitive ankle sprains were reported by 7 patients (47%). There was a statistically significant improvement in pain after surgery ($P < .001$) (Table 2). The mean AOFAS pain score was 20 (range unavailable) preoperatively versus 35 (range, 0 to 40) postoperatively. Type I complex regional pain syndrome (CRPS) developed in 1 patient (7%) after surgery. No other intraoperative or postoperative surgical complications occurred.

The calcaneus varization angle after the tiptoe standing test was 3.4° (range, 0° to 8°) preoperatively and 12.3° (range, 0° to 20°) postoperatively ($P < .001$). The mean preoperative and postoperative dorsal foot flexion angles were 16° (range, 4° to 40°) and 21.9° (range, 10° to 46°), respectively ($P < .001$). The mean plantar foot flexion angle was 39.4° (range, 36° to 44°) preoperatively and 42.9° (range, 30° to 56°) postoperatively ($P = .001$) (Table 2).

Preoperative CT scans showed that all TCCs involved the medial subtalar joint facet, and the TCCs were classified as Rozansky type I in 7 cases, type II in 3, type III in 3, and type IV in 3 (Table 1).[9] The mean Comfort-Johnson index was 40.8% (range, 33% to 50%). All postoperative CT scans at 1 year (n = 15) and 3 years (n = 5) showed complete synostosis resection with no recurrences at final follow-up.

In all cases the arthroscopic approach enabled complete resection of the TCC and visualization and restoration of the passive range of motion of the posterior talocalcaneal joint (Fig 2 G and H). Conversion to an open procedure was not required in any case.

All patients (100%) improved by at least 1 stage in the Johnson and Strom flatfoot classification[8] and showed clinical subtalar mobility (Figs 3 and 4). The mean preoperative and postoperative flatfoot Johnson and Strom scores were 1.56 (range, 0 to 3) and 0.5 (range, 0 to 2), respectively. These differences were statistically significant ($P = .005$) (Table 2).

The mean AOFAS score was 56.8 (range, 45 to 62) preoperatively versus 90.9 (range, 36 to 100) postoperatively, showing a significant increase ($P < .001$) (Table 2). At final follow-up, all patients were either satisfied (n = 4 [27%]) or extremely satisfied (n = 10

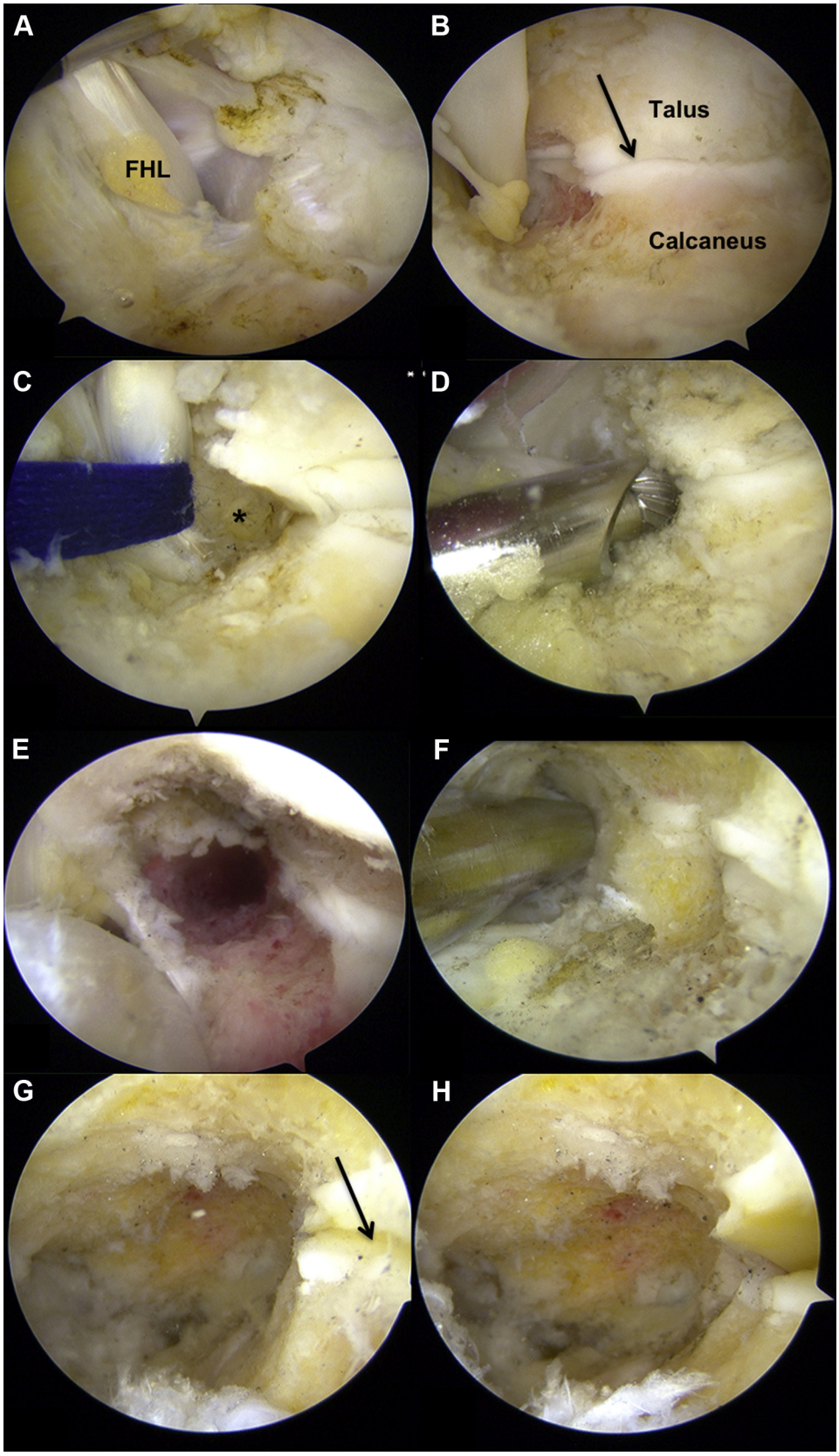

Fig 2. Arthroscopic images (right ankle). Visualization of (A) flexor hallucis longus (FHL) tendon and (B) posterior talocalcaneal joint (arrow). (C) The FHL is separated with a textile band, and the coalition is identified (asterisk). (D) A tunnel is created within the coalition with a burr; (E) a medial bone shell is thus preserved. (F) The bone shell is ablated with a Smillie knife. (G, H) Talocalcaneal joint motion is verified by performing varus-valgus calcaneus movements. The arrow indicates the subtalar joint.

Fig 3. (A-C) A right rigid flatfoot and severe hindfoot valgus deformity in a 13-year-old girl. (D) An arthroscopic talocalcaneal coalition resection combined with the calcaneo-stop technique was performed with a 6.5-mm spongious screw. (E, F) Static hindfoot valgus correction and subtalar motion restoration resulted.

[67%]) with the outcome, except the 1 patient (7%) in whom CRPS developed.

Discussion

In our study a posterior arthroscopic technique proved to be an effective alternative to the classic open resection for the treatment of TCCs in children, yielding comparable functional and patient-reported outcomes. The classic technique of open surgical resection and interposition fat grafting has shown satisfactory outcomes with low recurrence rates.[11,14,15] Gantsoudes et al.[14] reported good to excellent results in 85% of patients, as well as 93% improvement in ankle range of motion in 49 patients who were followed up for at least 12 months. The recurrence rate was 3%.

Arthroscopy is gaining popularity in the treatment of foot and ankle disorders in the pediatric population.[16,17] Knorr et al.[16] reported promising results with arthroscopic resection of calcaneonavicular coalitions in children. Posterior hindfoot arthroscopy has been used effectively in the treatment of numerous hindfoot conditions.[12,13] Some of the advantages of this procedure over open surgery are reduced postoperative pain, hospital stays, infection rates, and wound complication rates, as well as a more expeditious recovery.[12,13,17]

In the realm of TCC treatment, Bonasia et al.[4] adopted the posterior arthroscopic approach for posterior facet–type TCC excision. This type of TCC, Rozansky type V, accounts for only 16.7% of all coalitions.[9] Our technique also used a posterior arthroscopic approach but excised medial facet TCCs (Rozansky types I to IV) and, thus, required the surgeon to work and dissect more deeply. Numerous anatomic structures are at risk with this approach (FHL tendon, flexor digitorum longus tendon, and posterior tibialis neurovascular bundle); a precise and meticulous arthroscopic technique is therefore paramount. This posterior approach allowed the identification of these structures, thus allowing them to be protected. No neurovascular or tendinous complications occurred with our technique

Table 1. Patient Characteristics

Patient No.	Age, yr	Sex	Rozansky Classification	Follow-up, mo
1*	12	M	I/II	36
2	11	M	IV	44
3	11	F	II	40
4	8	M	II	37
5	13	F	I	36
6	11	M	I	26
7	10	M	I	31
8	15	F	III	32
9	14	F	I	33
10	10	M	III	34
11	14	M	IV	35
12	13	M	III	16
13	10	M	IV	13
14	12	M	I	13
15	13	F	I	12

F, female; M, male.
*The patient underwent bilateral procedures.

Table 2. Outcomes

Parameter	Preoperative			Postoperative			*P* Value
	Mean	SD	Range	Mean	SD	Range	
Calcaneus varization angle, °	3.4	3.1	0-8	12.3	5.4	0-20	< .001
Dorsal foot flexion, °	16	9.4	4-40	21.9	8.5	10-46	< .001
Plantar foot flexion, °	39.4	5.4	24-44	42.9	6.1	30-56	.001
AOFAS score	56.8	6.4	45-62	90.9	15.9	36-100	< .001
Pain score on AOFAS scale	20	0	—	35	10.3	0-40	< .001
Flatfoot score	1.56	1.3	0-3	0.5	0.7	0-2	.005

AOFAS, American Orthopaedic Foot & Ankle Society.

in this series. Jagodzinski et al.[18] described arthroscopic resection of TCCs using a lateral approach through the sinus tarsi. Of the 8 patients included in their study, 1 had a tibialis nerve injury that required nerve grafting. The lateral approach, although technically less demanding, does not allow visualization of the medial anatomic structures during coalition resection, thus putting them at risk of injury. The etiology of CRPS, which occurred in 1 patient in our study, remains unknown but was presumably unrelated to the arthroscopic procedure.[17]

The traditional medial open approach to the subtalar joint provides excellent exposure of the middle facet but, on the contrary to our technique, provides inadequate visualization of the posterior facet and thus a limited assessment of subtalar motion, cartilage quality, and adequacy of synostosis resection.[18,19] Field and Ng,[19] to overcome these drawbacks, combined a medial open approach for coalition resection and a lateral arthroscopic approach for subtalar joint assessment.

Tissue interposition after resection of the coalition has been performed with the purpose of decreasing the risk of recurrence.[11,14,15] However, some authors have reported good results without interposing any tissue.[20] No comparative studies between the techniques are available. We opted not to interpose any tissue after resection and observed no recurrences. The fact that we promoted early postoperative active and passive foot and ankle mobilization and resumption of weightbearing activities, in contrast to prolonged immobilization with a short leg cast in the classic technique, may have contributed to the absence of recurrences.

Painful TCCs in children are related to hindfoot stiffness but also hindfoot valgus.[2] Thus, marked hindfoot valgus deformity warrants simultaneous or delayed correction to optimize outcomes.[14,15,21] Even for unresectable TCCs, isolated hindfoot valgus correction has been shown to be able to relieve pain.[2,22,23] Gantsoudes et al.[14] reported that one-third of patients undergoing TCC resection needed a calcaneus osteotomy at a later date for hindfoot realignment. Wilde et al.[11] found that all the patients in their series with poor outcomes after TCC resection had preoperative CT scans on which hindfoot valgus measured greater than 16°. Luhmann and Schoenecker[15] noted that poorer outcomes occurred in patients whose preoperative hindfoot valgus measured more than 21°. We opted to perform a simultaneous correction of hindfoot alignment in children with CT scans showing valgus greater than 20° using another minimally invasive procedure, the calcaneo-stop technique.[3,5]

Several techniques have been used for the correction of hindfoot valgus deformity associated with TCCs: posterior calcaneus lateral opening-wedge osteotomy,[20,23]

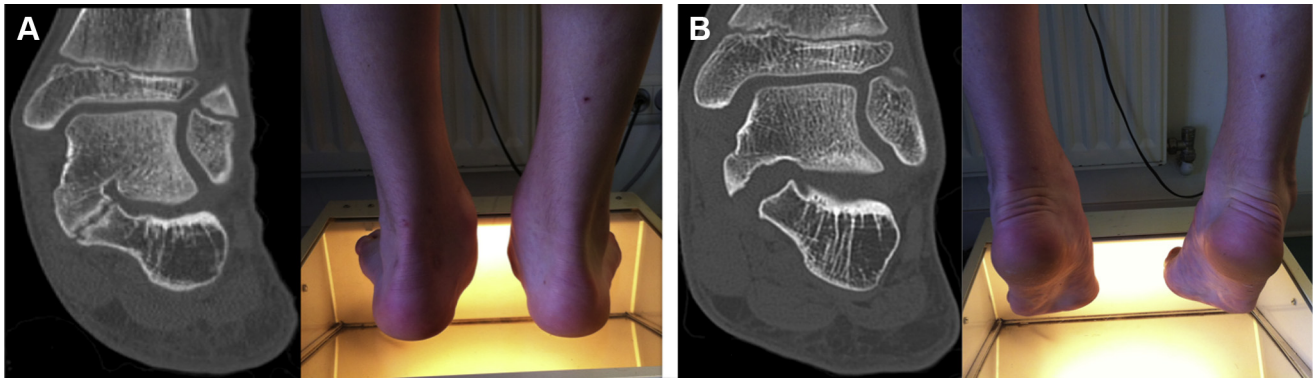

Fig 4. (A) A 13-year-old boy presented with a right rigid flatfoot and talocalcaneal coalition, as shown on computed tomography. (B) One year after arthroscopic talocalcaneal coalition resection, he showed no recurrence of the coalition and showed normal subtalar joint motion.

medial closing-wedge osteotomy of the posterior part of the calcaneus,[22] anterior calcaneal lengthening osteotomy,[2] lateral column lengthening,[15,20] and arthroereisis.[21] The calcaneo-stop technique was originally described by Recaredo Alvarez in 1976 for the treatment of symptomatic severe flexible flatfoot in children.[3,5] This arthrodesis-type procedure to limit motion of the subtalar joint is simple, reliable, and minimally invasive and has been associated with excellent long-term reported outcomes.[3,5,24] Pavone et al.[3] reported successful hindfoot valgus correction in 97% of cases and footprint normalization in 80%. Similarly, all of our patients showed postoperative improvement in the degree of hindfoot valgus.

Limitations

The main limitation of our study is the limited number of patients included. Additional limitations include the lack of a control group and the fact that the calcaneo-stop procedure might act as a confounding variable.

Conclusions

Arthroscopic TCC resection provides good outcomes (symptom relief and restoration of subtalar motion), with no recurrence of the coalition.

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