Management of symptomatic flexible flatfoot in adolescents by Mosca's lateral calcaneal lengthening

Abdel-Salam A. Ahmed

Department of Orthopaedic Surgery, Faculty of Medicine, Benha University, Benha, Egypt

Correspondence to Abdel-Salam A. Ahmed, MD, Department of Orthopaedic Surgery, Benha Faculty of Medicine, Farid Nada Street, Kalyubia, Benha, PO Box 13518, Benha, Egypt.
Tel: +20 114 437 0370/+20 133 263 343;
e-mails: salam_ilizarov@yahoo.com and
e-mail: abdelsalam.youssef@fmed.bu.edu.eg

Received 28 March 2016
Accepted 17 May 2016

The Egyptian Orthopaedic Journal
2016, 51:1–7

Introduction
There is considerable debate as to the ideal procedure for the treatment of symptomatic flexible flatfoot (FFF) that is not followed by recurrence and that minimizes complications. The purpose of the present study was to evaluate the results of calcaneal lengthening using Mosca's technique in adolescents with FFF in whom conservative treatment had been applied for more than 1 year but had failed.
Patients and methods
Calcaneal lengthening osteotomy was performed using Mosca's technique in 14 patients including ten males and four females. Five cases were bilateral making the total of 19 feet. The mean age at surgery was 13.53 (range 11.5–16) years. All FFF patients were evaluated as idiopathic. Bilateral cases were operated on at two sessions with an average interval of 15.6 (range 12–21) months. The American Orthopaedic Foot and Ankle Society ankle-hind foot scale was used for clinical assessment, and radiographic assessment was based on six parameters on standard anteroposterior and lateral radiographs.
Results
The mean follow-up period was 27.89 (range 18–44) months. The mean American Orthopaedic Foot and Ankle Society score increased from 57.53 preoperatively to 96.32 postoperatively. All radiographic parameters significantly improved. Four patients had mild occasional pain. There was no nonunion nor secondary subsidence of the arch. All patients stated that they were satisfied with the procedure.
Conclusion
Correction of FFF deformity with Mosca's lateral calcaneal lengthening was an effective and reproducible method to restore normal foot alignment and good function.

Keywords:
bone lengthening, calcaneus surgery, flatfoot, foot deformities, planovalgus foot

Egypt Orthop J 51:1–7

1110-1148

Introduction

Flatfoot is a complex foot deformity that is commonly seen in clinical practice. It is characterized by a combination of a collapse of the medial longitudinal arch, foot abduction and hind-foot valgus [1,2]. Harris and Beath [3] subdivided flatfeet into three types: flexible flatfoot (FFF), FFF with a short Achilles tendon and rigid flatfoot most commonly associated with tarsal coalitions. In a FFF, the longitudinal arch can be created by dorsiflexing the great toe and on toe-standing, because of the 'windlass action' of the plantar fascia [4,5]. FFF is a normal foot shape that is present in most infants and many adults, and the longitudinal arch elevates in most children spontaneously within the first decade of life [2,4,6].

There is broad consensus that an asymptomatic patient with FFF needs no specific treatment. Shoe inserts have been proven to be ineffective in correction of the deformity, but it may relieve symptoms in some cases. Therefore, in symptomatic patients who are unresponsive to conservative measures, surgery is often considered [4–7].

Numerous surgical procedures to correct flatfoot have been proposed and can be categorized as soft-tissue reconstruction, osteotomies, arthroereisis and arthrodesis [6–9]. Solely soft-tissue procedures, arthrodesis and arthroereisis have shown unsatisfactory outcomes. Therefore, many investigators have suggested that joint-sparing procedures, such as lateral column lengthening and calcaneal osteotomy, should be the treatment of choice for correcting planovalgus foot deformities in children and adolescents [6,8–10].

 DOI: 10.4103/1110-1148.194428

The purpose of this study was to evaluate the radiological and clinical outcomes of Mosca's technique for lateral calcaneal lengthening in adolescents with symptomatic FFF after failure of conservative treatment.

Patients and methods

This was a retrospective study undertaken at Benha University Hospital, Egypt and approved by Research Ethics Committee of the University. From January 2006 until March 2014, lateral calcaneal lengthening using Mosca's technique was performed for 14 patients with FFF, including five bilateral cases and a total of 19 feet. There were 12 right FFF and seven left FFF. Four patients were female and 10 were male, and none had undergone surgery for the deformity. The mean age at surgery was 13.53 years (SD 1.38; range 11.5–16). Inclusion criteria included adolescents with painful FFF in whom conservative measures such as insoles and physical therapy had been applied for more than 1 year but failed. Cases of rigid flatfoot, post-traumatic flatfoot and painful flatfoot for reasons other than loss of the arch were excluded from this study. All FFF cases were evaluated as idiopathic and had collapse of the medial longitudinal arch, forefoot abduction and hind-foot valgus. A general examination was carried out to assess the evidence of generalized ligamentous laxity that was present in six patients. The flexibility was confirmed, and the thigh-foot angle and the transmalleolar axis were assessed with the patient prone (Fig. 1). Ankle dorsiflexion was limited by a tight heel cord in 12 patients, as identified by the Silfverskiöld test.

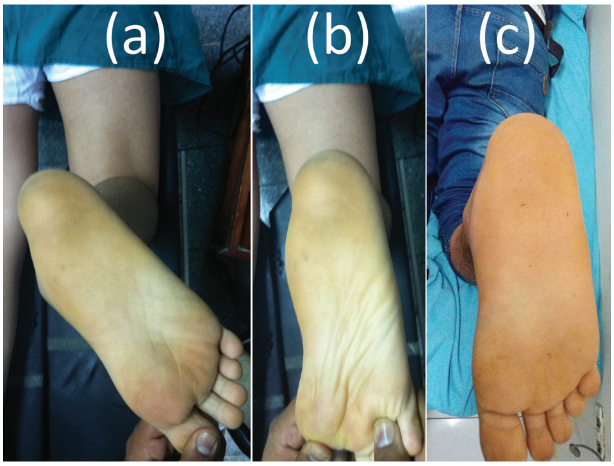
Clinical evaluation was carried out with the American Orthopaedic Foot and Ankle Society (AOFAS) ankle-hind foot scale. The AOFAS ankle-hind foot scale, an assessment tool widely accepted in the orthopaedic foot and ankle community, is a 100-point score comprising 40 points for pain, 50 points for function and 10 points for alignment [11]. The preoperative AOFAS ankle-hind foot score ranged from 53 to 72 with a mean of 57.53 (SD 6.62). Radiographic assessment was based on six parameters on standard anteroposterior (AP) and lateral radiographs. The talonavicular coverage, AP talus-first metatarsal angle, AP talocalcaneal angle, calcaneal pitch, Costa Bertani angle and the lateral talocalcaneal angle were evaluated (Table 1).

Before surgery, we discussed the procedure in detail with the patients and their families. Informed consent was obtained from the parents or guardians of all patients included in the study.

Operative technique

The surgical technique used was basically the same as that reported by Mosca and colleagues [5,6,10]. The patient, under general anaesthesia with a thigh tourniquet, was placed in the supine position with a sandbag under the ipsilateral buttock to aid access to the lateral side of the foot. The patient was prepared from the iliac crest to the toes. A modified Ollier incision was made and the sinus tarsi was exposed. The peroneus longus and the peroneus brevis tendons were released

Figure 1



Prone thigh-foot angle assessment. (a) Preoperative externally rotated thigh-foot angle. (b) Neutral thigh-foot angle created by inverting the subtalar joint preoperatively. (c) Thigh-foot angle after deformity correction.

Table 1 Preoperative and postoperative radiographic measures

Parameters	Preoperative	Postoperative	*P value
AP			
Talonavicular coverage	Mean 28.42; SD 3.83; range 20–35	Mean 4.37; SD 1.98; range 2–10	0.000
Talus-first metatarsal angle	Mean 27.68; SD 4.36; range 20–37	Mean 3.16; SD.96; range 2–5	0.000
Talocalcaneal angle	Mean 45.95; SD 4.56; range 39–53	Mean 23.63; SD 8.01; range 15–51	0.000
LAT			
Calcaneal pitch	Mean 4.26; SD.93; range 3–7	Mean 19.47; SD 2.01; range 17–23	0.000
Costa Bertani angle	Mean 152.32; SD 4.88; range 145–161	Mean 127.89; SD 3.65; range 123–135	0.000
Talocalcaneal angle	Mean 51.89; SD 3.74; range 44–58	Mean 36.47; SD 5.66; range 28–45	0.000

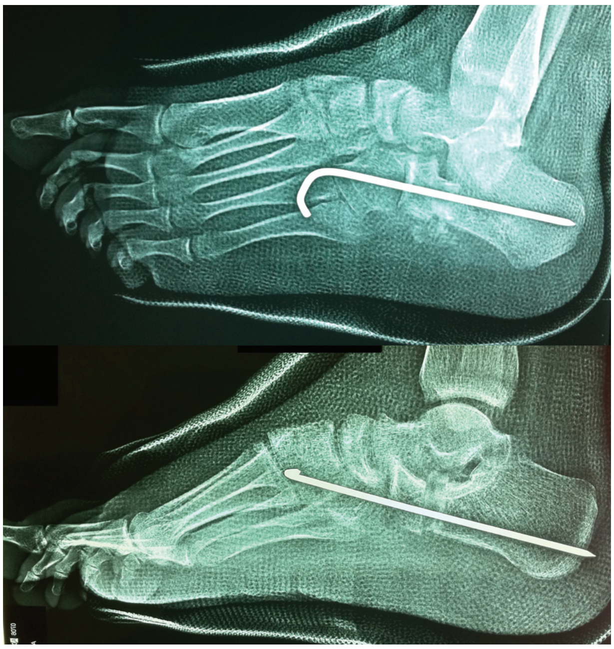
AP, anteroposterior; LAT, lateral. *The paired *t*-test was used to evaluate the statistical significance between the preoperative and postoperative measurements.

with Z-cutting of the peroneus brevis tendon. A longitudinal incision along the medial border of the foot was made. The tibialis posterior tendon was released and cut in a Z-manner. Percutaneous Achilles tendon lengthening was performed if required.

An oblique calcaneal osteotomy was performed from posterolateral to anteromedial between the anterior and middle facets about 2 cm posterior to the calcaneocuboid joint. With the foot in the original everted position, a Kirschner wire was inserted from the cuboid distally across the calcaneocuboid joint to avoid its subluxation with osteotomy distraction. An ipsilateral bicortical trapezoid-shaped iliac crest bone graft was harvested through a standard apophyseal-splitting approach. Using a spreader, the osteotomy was then opened and the bone graft was inserted. The degree of correction was checked clinically and with fluoroscopy. The peroneus brevis tendon was repaired after lengthening.The proximal slip of the tibialis posterior was advanced ~5 to 7 mm through a slit in the distal stump of the tendon and repaired as a Pulvertaft weave. Medial and plantar capsular imbrication of the talonavicular joint was performed. The incisions were closed and a well-padded short-leg non-weight-bearing cast was applied (Fig. 2).

Postoperatively, the cast was kept for 8 weeks. Patients were assessed clinically and radiographically weekly for the first month, biweekly for the second month until fusion

Figure 2



The postoperative radiographs.

and then every 6 months. The patients were monitored for the state of wounds, pin site, maintenance of correction and progression of fusion. The pin was removed after 6 weeks and the cast was changed. Weight bearing was not permitted until union. A medial arch support was used for 4 months, after which patients were allowed to stop using it. At the final follow-up, the outcome was assessed by the six radiographic parameters and clinically by the AOFAS ankle-hind foot scale.

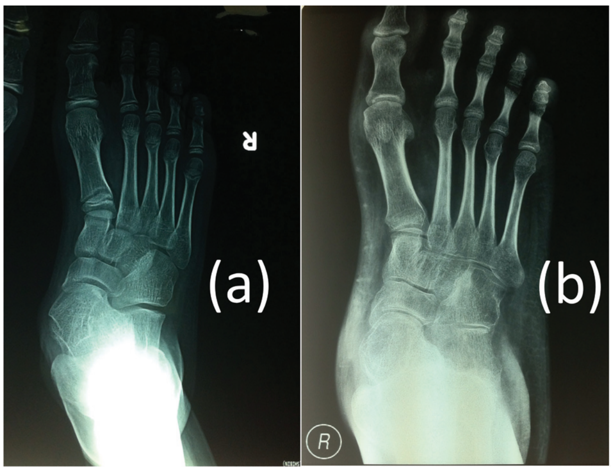
Statistical analysis

The qualitative variables (sex and side) were expressed as an absolute value (*n*), frequencies and percentages, whereas the quantitative variables (age, time to union, follow-up duration, radiographic parameters and AOFAS ankle-hind foot scores) were expressed as mean, SDs and ranges. Statistical analysis was performed to compare the mean preoperative and postoperative radiographic parameters and AOFAS scores using Student's *t*-test. Level of significance was set at *P* value less than 0.05. The descriptive analysis and statistical analysis were performed with IBM SPSS Statistics for Windows, version 22.0 (IBM Corp., Armonk, New York, USA).

Results

Patients were followed up for a mean of 27.89 (SD 8.67; range 18–44) months. Bilateral cases were operated on at two sessions with an average interval of 15.6 (SD 3.91; range 12–21) months. All osteotomies healed in a mean of 7.21 (SD.713; range 6–8) weeks. The talonavicular coverage was significantly decreased postoperatively ($P=0.000$) in all cases. The AP talus-first metatarsal angle, AP talocalcaneal angle, Costa Bertani angle and the lateral talocalcaneal angle were significantly decreased ($P=0.000$) after calcaneal lengthening.

Figure 3



Anteroposterior radiographs of a flexible flatfoot (a) preoperatively and (b) postoperatively at 18 months of follow-up.

Calcaneal pitch angle was significantly increased after the operation ($P=0.000$) (Figs. 3 and 4 and Table 1). At the final follow-up, AOFAS ankle-hind foot score ranged from 82 to 100, with a mean of 96.32 (SD 5.83) with statistically significant improvement from the mean preoperative score of 57.53 ($P=0.000$).

Four patients had mild occasional pain. One case of superficial wound infection was encountered and was treated with frequent antiseptic dressing changes and oral antibiotics. Delayed healing of the lateral incision occurred in five cases without signs of infection and was managed by repeated dressing. There were no pin-related complications. No cases of postoperative deep infections, nonunion or calcaneocuboid subluxation were encountered. There were no problems at the donor site or subluxation of the graft. Patients were asked about the satisfaction with their postoperative situation. All patients stated they were satisfied with the procedure (Figs. 5–7).

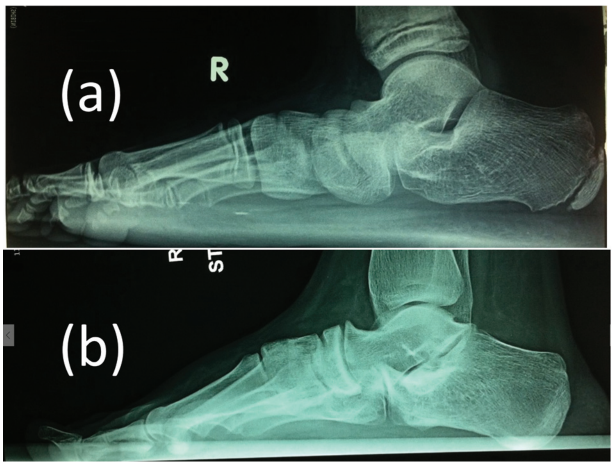
Discussion

Flatfoot is a very commonly seen deformity in children and adolescents, most of which are flexible. Most authors currently agree that FFF may be considered an anatomic variant and is not a disabling deformity. The usual indication for surgery in FFF is pain that does not respond to conservative management [4–9].

Numerous surgical procedures to correct flatfoot have been described. Surgeries that rely entirely on soft-tissue procedures are known to stretch out and fail in the short term. Arthrodesis of one or more of the joints in the subtalar complex has a detrimental effect of eliminating the shock-absorbing function and shifts stress to the ankle and mid-tarsal joints leading to premature degenerative arthrosis at those sites. Therefore, present surgical recommendations focus on preservation of subtalar motion [6,8,12,13].

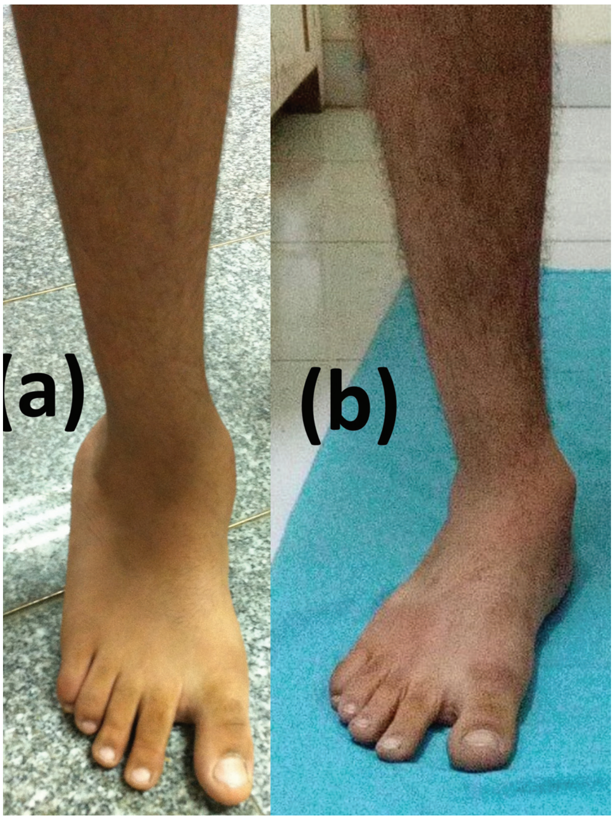
Advocates of subtalar arthroereisis suggest that it is minimally invasive and preserves subtalar joint motion [4]. Despite reports of good outcomes, it has associated

Figure 4



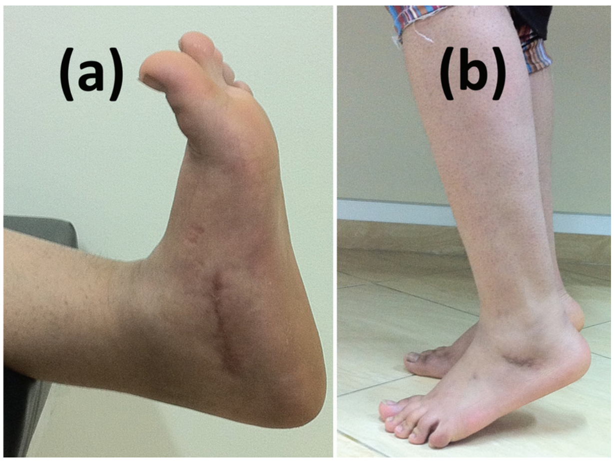
Lateral radiographs of the case in Fig. 3 3(a) preoperatively and (b) postoperatively at 18 months of follow-up.

Figure 5



Clinical photos showing (a) the preoperative planovalgus deformity and (b) the postoperative deformity correction.

Figure 6



Postoperative clinical photos showing tip-toe standing and active range of motion without heel cord tightness.

Figure 7

Clinical photograph of the hind feet in a patient with bilateral flexible flatfoot demonstrating the left foot after correction compared with the nonoperated right side.

complications. The complications include those associated with biomaterials problems (breakage, degradation), inappropriate implantation (overcorrection, undercorrection, malpositioning, extrusion of implant, wrong size of implant) and biologic problems (implant-induced sinus tarsi impingement pain, foreign-body reaction, synovitis, infection, intraosseous cystic formation in the talus, avascular necrosis of the talus, peroneal spasm, calcaneus fracture and stress fractures of the fourth metatarsal) [4,13,14].

Osteotomy is the last category of procedures that has been used to treat flatfeet. The posterior calcaneus displacement osteotomy does not actually correct the malalignment of the subtalar joint, but merely creates a compensating deformity to improve the valgus angulation of the heel [13]. Vander Griend [15] described a Z-lengthening osteotomy of the calcaneus. This is more technically demanding, with probably more risk to damaging medially based structures. In 1975, Evans [16] originally described treatment of planovalgus deformity with lateral column lengthening using autogenous tibial cortical bone graft. In 1995, the technique was modified and further developed by Mosca [10] who described the specific location and direction of the osteotomy (exiting medially between the anterior and middle facets), and the trapezoidal shape of the bone graft. This was based on the observation that the centre of rotation for the correction is near the centre of the talar head and not simply the medial calcaneal cortex; thus, the osteotomy is a distraction wedge and not a simple opening wedge or plain distraction. In addition, Mosca described the management of the medial and lateral soft tissues, the need to temporarily stabilize the calcaneocuboid joint and the need to assess and concurrently manage contracture of the Achilles tendon [5,6,10]. In the present study, percutaneous Achilles tendon lengthening was performed in 12 cases. In these cases, the Silfverskiöld test showed less than 10° of dorsiflexion with the knee both flexed and extended, indicating that the entire triceps surae was contracted and Achilles tendon lengthening was required. On the other hand, if at least 10° of dorsiflexion is possible with the knee flexed, but not with the knee extended, the gastrocnemius muscle alone is contracted and an isolated gastrocnemius recession should be performed [17]. Rebalancing the forces that act on the arch can improve function and lessen the chance for further or subsequent development of deformity [18].

In this series, the deformity was corrected in all cases with significant improvement in radiographic parameters and AOFAS ankle-hind foot score. There were very few minor surgical complications. Lateral incision wound healing was delayed in five cases. This might be explained by acute lateral soft-tissue stretch. There was no calcaneocuboid subluxation, perhaps because of stabilization by the Kirschner wire.

It is difficult to compare our results with other authors because the reported series presented several aetiologies; used inconsistent operative techniques; had variations in patient age; and lacked standardized outcome measures. For example, Adams *et al.* [19] found a significantly increased proportion of calaneocuboid subluxation after lateral column lengthening in children with cerebral palsy. Ettl *et al.* [20] had no calaneocuboid subluxation on using Mosca's technique. Kim *et al.* [8] reported three cases of subluxation in 28 feet. Despite the excellent correction of deformity obtained by the use of lateral column lengthening for FFF, some authors have reservations about its use because of reported secondary increases in the calcaneocuboid joint pressures [21]. However, the recent work of Xia *et al.* [22] found that lateral column lengthening using the Evans procedure can decrease the abnormally high pressure across the calcaneocuboid joint in the flatfoot. Ahn *et al.* [23] reported that the calcaneocuboid joint subluxation was gradually resolving over time, with no evidence of osteoarthritic change in the calcaneocuboid joint. Ragab *et al.* [24] reported that a calcaneal lengthening osteotomy might violate the subtalar joint and have potentially deleterious long-term effects. However, this result has not been borne out by any published data [13].

In this study, the mean AOFAS score increased from 57.53 preoperatively to 96.32 postoperatively. This was better than the score of 71.9 reported by Haeseker *et al.*[25] after distraction arthrodesis. However, it was comparable to other studies. Akimau and Flowers [12] reported an AOFAS score of 87 ± 14 after lateral column lengthening. Klaue *et al.* [26] reported an increase in AOFAS score from 50 to 90 with a central calcaneal osteotomy. Oh *et al.* [27] in their study of 10 adolescents and young adults showed AOFAS scores increasing from 49.1 to 93.4 after combined medializing calcaneal osteotomy and lateral column lengthening in the symptomatic flatfoot.

The advantages of calcaneal lengthening osteotomy are as follows: it is technically easy to be applied, has a low risk of neurovascular injury and low loss of blood. In addition, it allows other procedures to be applied in the future contrary to arthrodesis. If arthrodesis is required later in these feet, it will be far easier to do because of the corrected alignment of the foot. However, future long-term studies may be needed to detect any deleterious effects on the subtalar joint caused by the osteotomy.

Limitations of the present study are that it is retrospective and has small numbers of patients.

Conclusion

Calcaneal lengthening using the Mosca's technique was effective in deformity correction and pain relief of painful FFF in adolescents. The procedure corrected all components of FFF while preserving subtalar joint motion. The technique is reproducible with minor complications.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1 Arunakul M, Amendola A, Gao Y, Goetz JE, Femino JE, Phisitkul P. Tripod index: a new radiographic parameter assessing foot alignment. Foot Ankle Int 2013; 34:1411–1420.

2 Pita-Fernández S, González-Martín C, Seoane-Pillado T, López-Calviño B, Pértega-Díaz S, Gil-Guillén V. Validity of footprint analysis to determine flatfoot using clinical diagnosis as the gold standard in a random sample aged 40 years and older. J Epidemiol 2015; 25:148–154.

3 Harris RI, Beath T. Army foot survey: an investigation of foot ailments in Canadian soldiers. Ottawa, ON:National Research Council of Canada, 1947; 1–268.

4 De Pellegrin M, Moharamzadeh D, Strobl WM, Biedermann R, Tschauner C, Wirth T. Subtalar extra-articular screw arthroereisis (SESA) for the treatment of flexible flatfoot in children. J Child Orthop 2014; 8:479–487.

5 Mosca VS. Flexible flatfoot in children and adolescents. J Child Orthop 2010; 4:107–121.

6 Mosca VS. Management of the painful adolescent flatfoot. Tech Foot Ankle Surg 2014; 13:3–13.

7 MacKenzie AJ, Rome K, Evans AM. The efficacy of nonsurgical interventions for pediatric flexible flat foot: a critical review. J Pediatr Orthop 2012; 32:830–834.

8 Kim JR, Shin SJ, Wang SI, Kang SM. Comparison of lateral opening wedge calcaneal osteotomy and medial calcaneal sliding-opening wedge cuboid-closing wedge cuneiform osteotomy for correction of planovalgus foot deformity in children. J Foot Ankle Surg 2013; 52:162–166.

9 Sekiya JK, Saltzman CL. Long term follow-up of medial column fusion and tibialis anterior transposition for adolescent flatfoot deformity. Iowa Orthop J 1997; 17:121–129.

10 Mosca VS. Calcaneal lengthening for valgus deformity of the hindfoot. Results in children who had severe, symptomatic flatfoot and skewfoot. J Bone Joint Surg Am 1995; 77:500–512.

11 Kitaoka HB, Alexander IJ, Adelaar RS, Nunley JA, Myerson MS, Sanders M. Clinical rating systems for the ankle-hindfoot, midfoot, hallux, and lesser toes. Foot Ankle Int 1994; 15:349–353.

12 Akimau P, Flowers M. Medium term outcomes of planovalgus foot correction in children using a lateral column lengthening approach with additional procedures'a la carte'. Foot Ankle Surg 2014; 20:26–29.

13 Mosca VS. The foot. In: Weinstein SL, Flynn JM, eds. Lovell and Winter's pediatric orthopaedics. 7th ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2014;1388–1525.

14 Kumar V, Clough TM. Talar neck fracture-a rare but important complication following subtalar arthroereisis. Foot (Edinb) 2014; 24:169–171.

15 Vander Griend R. Lateral column lengthening using a 'Z' osteotomy of the calcaneus. Tech Foot Ankle Surg 2008; 7:257–263.

16 Evans D. Calcaneo-valgus deformity. J Bone Joint Surg Br 1975; 57:270–278.

17 Bouchard M, Mosca VS. Flatfoot deformity in children and adolescents: surgical indications and management. J Am Acad Orthop Surg 2014; 22:623–632.

18 Van Boerum DH, Sangeorzan BJ. Biomechanics and pathophysiology of flat foot. Foot Ankle Clin 2003; 8:419–430.

19 Adams SB, Simpson AW, Pugh LI, Stasikelis PJ. Calcaneocuboid joint subluxation after calcaneal lengthening for planovalgus foot deformity in children with cerebral palsy. J Pediatr Orthop 2009; 29:170–174.

20 Ettl V, Wollmerstedt N, Kirschner S, Morrison R, Pasold E, Raab P. Calcaneal lengthening for planovalgus deformity in children with cerebral palsy. Foot Ankle Int 2009; 30:398–404.

21 Cooper PS, Nowak MD, Shaer J. Calcaneocuboid joint pressures with lateral column lengthening (Evans) procedure. Foot Ankle Int 1997; 18:199–205.

22 Xia J, Zhang P, Yang YF, Zhou JQ, Li QM, Yu GR. Biomechanical analysis of the calcaneocuboid joint pressure after sequential lengthening of the lateral column. Foot Ankle Int 2013; 34:261–266.

23 Ahn JY, Lee HS, Kim CH, Yang JP, Park SS. Calcaneocuboid joint subluxation after the calcaneal lengthening procedure in children. Foot Ankle Int 2014; 35:677–682.

24 Ragab AA, Stewart SL, Cooperman DR. Implications of subtalar joint anatomic variation in calcaneal lengthening osteotomy. J Pediatr Orthop 2003; 23:79–83.

25 Haeseker GA, Mureau MA, Faber FW. Lateral column lengthening for acquired adult flatfoot deformity caused by posterior tibial tendon dysfunction stage II: a retrospective comparison of calcaneus osteotomy with calcaneocuboid distraction arthrodesis. J Foot Ankle Surg 2010; 49:380–384.

26 Klaue K, Kaliyaperumal K, Swanson SA, Low WC. Central calcaneal osteotomy for correction of flexible pes planovalgus deformity. Foot Ankle Int 2013; 34:1079–1089.

27 Oh I, Williams BR, Ellis SJ, Kwon DJ, Deland JT. Reconstruction of the symptomatic idiopathic flatfoot in adolescents and young adults. Foot Ankle Int 2011; 32:225–232.