Calcaneal-stop procedure for treatment of pediatric flexible flatfoot

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Received: 2 September 2021
Revised: 25 January 2022
Accepted: 6 February 2022
Published: 31 May 2022

The Egyptian Orthopaedic Journal 2022, 57:66–71

Background

Flexible flatfoot is a common problem of premature patients. There are different procedures described for the treatment of this condition. The calcaneal stop is an easy and simple procedure for its treatment. In this study, we evaluate this technique as a valuable one.

Patients and methods

This study was performed on 20 feet in 12 patients (seven males and five females) with flexible flatfeet (eight bilateral and four unilateral cases) who were treated with a calcaneal-stop procedure. They had the following inclusion criteria: (a) skeletal-immaturity patients; (b) symptomatic flexible flatfoot deformity (pain, function, and activity limitations) not responsive to conservative treatment. The evaluation was done clinically by American Orthopedic Foot and Ankle Society Ankle–Hindfoot score, and hindfoot valgus angle. Radiological evaluation was done by calcaneal-pitch angles, Kite's angle, talar-declination angle, lateral Meary's angle, and talonavicular-coverage angle.

Results

Clinical and functional outcomes of all patients were evaluated, before surgery, and at 3 and 6 months after surgery. The American Orthopedic Foot and Ankle Society score mean increased from 70.6 (SD 4.8) to 88.4 (SD 7.4) at the end of the study. Heel valgus improved from 11.45 (SD 3.02) to 2.7 (SD 1.3) at the end of the study. The calcaneal-pitch angle increased from 13.4 (SD 1.1) to 16.1 (SD 1.4) at the end of the study. Talar-declination angle decreased from 41.9 (SD 5.0) to 32.8 (SD 4.5) at the end. Kite angle changed from 29.6 (SD 3.1) preoperatively to 26.7 (SD 2.7) finally. Talonavicular-coverage angle improved from 22.4 (SD 5.4) to 11.2 (SD 5.68) at the end. Lateral Meary's talocalcaneal angle decreased from 20.55±6.9 to 14.3 ±4.73 at 6 months after surgery. There was significant satisfaction of 11 (91.6%) patients with one patient who showed some pain at the site of operation with no need for screw removal.

Conclusion

There was significant improvement ($P<0.00001$) of all clinical and radiological parameters. The changes were mainly after surgery. There was an increased improvement with time, however, it was not statically significant. The main problem of flatfeet is patient dissatisfaction, which requires intervention. The calcaneal-stop procedure is an easy and simple procedure, with a minimal complication for the management of flexible flatfeet.

Keywords:
calcaneo stop, flexible flatfoot, pediatric patient, sport

Egypt Orthop J 57:66–71

1110-1148

Introduction

Flexible flatfoot is one of the most common deformities of the human body. This condition may be asymptomatic, but it can also cause pain, difficulty in walking, and physical impairment [1]. Flexible flatfoot is characterized by a normal medial arch during nonweight bearing or tip toeing and an absence of the medial arch accompanied by a medial protrusion of the head of the talus and a valgus position of the calcaneus underweight bearing [2].

The surgical techniques used to correct this deformity can be grouped into three categories: soft tissue, bony (osteotomies and arthrodesis), and arthroereisis. The first (soft tissue) should always be combined with bone or arthroereisis, as a stable, lasting correction is rarely obtained with the application of the soft-tissue procedure alone [3].

Arthroereisis procedures were originally designed for pediatric treatment and generally involve joint-sparing

 DOI: 10.4103/eoj.eoj_108_21

techniques that correct the flatfoot deformity while preserving foot function. This approach was first described by Grice in 1952 'for correction of paralytic flatfeet in children'. Haraldsson and Lelievre first pointed out the possibility of blocking the sinus tarsi, restricting subtalar motion avoiding any fusions. This technique is the birth of the arthroereisis procedures, with Lelievre introducing the term lateral arthroereisis for a temporary staple across the subtalar joint [4].

Recaredo developed a calcaneo-stop procedure. He inserted a cancellous screw into the calcaneus bone to interfere with talus movement in proximity of the screw head. The entry point was located in the sinus tarsi. Usuelli *et al.* [5] reported 83% good results in 475 cases with 12–112 months follow-up time with this procedure.

An interesting phenomenon described for both sinus tarsi arthroereisis and the calcaneo-stop procedures is the maintenance of the correction even after hardware removal. It is likely that this finding has biomechanics and neuroproprioception explanations [6].

There is no absolute contraindication for implant insertion inside pediatric joints. Contraindications to arthroereisis include active infection, advanced subtalar arthrosis, neurological flatfoot, ligamentous laxity, clubfoot sequelae, or previous traumatic or surgical wound overlying the sinus tarsi [7,8]. Even some authors recommend this procedure for patients with tarsal coalition after removal of coalition [8]. In their recent retrospective study, Indino *et al.* [9] suggested that endorthesis in pediatric flexible flatfoot was effective for improving radiographic parameters at skeletal maturity.

Usuelli and Montrasio [5] stated that although calcaneal stop was designed for pediatric flexible flatfoot, it can be used theoretically for adult flatfoot. In recent years, with the improved understanding of flexible flatfeet and the development of the subtalar-joint arthroereisis, which can allow a certain range of motion. It is gradually accepted by orthopedic surgeons [10].

In level-2-evident study of Memeo *et al.* [11], they stated that when exosinotarsal arthroereisis with metallic screw and endosinotarsal with bioabsorbable devices were compared, no statistical differences were found between the two techniques; the choice can be determined mostly by the surgeon's preference.

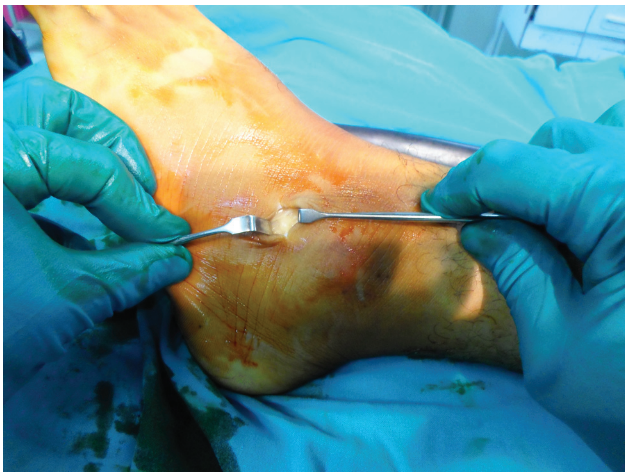
Patients and methods

A total of 20 feet in 12 consecutive patients with flexible flatfeet were treated with calcaneal-stop procedure. They had the following inclusion criteria: (a) skeletal immaturity with growth cartilage visible on preoperative foot radiographs; (b) symptomatic flexible flatfoot deformity (pain, function, and activity limitations) not responsive to conservative treatment; and for (c) surgical treatment with calcaneal-stop procedure. The exclusion criteria included those patients diagnosed with neurological or neuromuscular disorders, or post-traumatic flatfoot. The study was approved by the institutional ethics committee in the orthopedic Department of Orthopedic Surgery, Benha University, Egypt. The legal consents were taken from parents.

All patients should undergo conservative treatment for at least 3 months. We insisted on excluding and deposing the parents' habits for treating mearly visible deformities. Even when the parents told that their children had been already undergoing conservative treatment before coming, the conservative management should be done under the concerned surgeon himself. Many parents come even at an early age of their children asking for correction of nonsymptomatic or even physiological pes planus. Thus, surgeons should not start any type of surgical management, until they are completely confirmed about the pain and function affection of flatfeet affecting patient life with no response to conservative treatment.

The surgical technique was the calcaneo-stop procedure [12]. The surgery is performed under

Figure 1

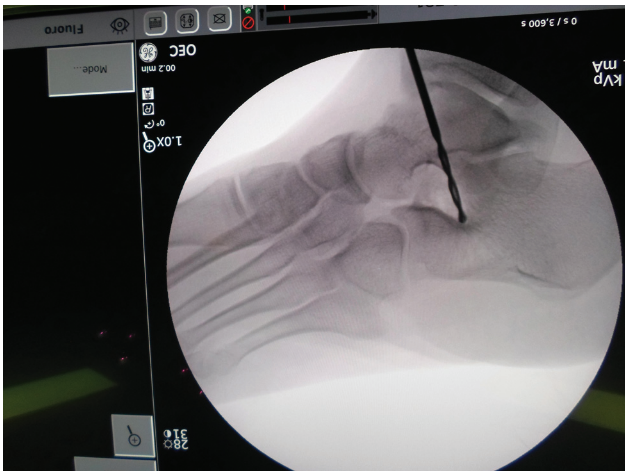


Incision at sinus tarsi.

general anesthesia. A tourniquet is applied proximally to the leg. Patients are placed in a supine position with the foot internally rotated. A 2-cm incision is made under the skin lines on the lateral aspect of the sinus tarsi (Fig. 1). Soft-tissue dissection is performed bluntly. Then, under radiographic control, a 3.2-mm drill bit is inserted vertically (Fig. 2) in the calcaneus from superior to inferior opposite to the sinus tarsi after reduction of the subtalar eversion, followed by insertion of a 4.5-mm cancellous screw with a length of 30–35 mm as a calcaneal-stop screw (Fig. 3) so that the screw head impinges against the lateral process of the talus, preventing eversion at the subtalar joint. The dorsiflexion of the foot is evaluated with the knee extended, once appropriate placement of the screw had been radiographically verified in the neutral position. Concomitant lengthening of the gastrocnemius or Achilles tendon can be done, if dorsiflexion in the neutral position after screw implantation is not possible at least to 5–10°. All patients were subjected to the rehabilitation protocol, consisting of proprioceptive exercises and stretching, avoiding running and jumping for the subsequent 2 months. After 4–6 weeks, patients undertake clinical and radiographic follow-up. After 2 months postoperatively, each patient is encouraged to practice their favorite sporting activity.

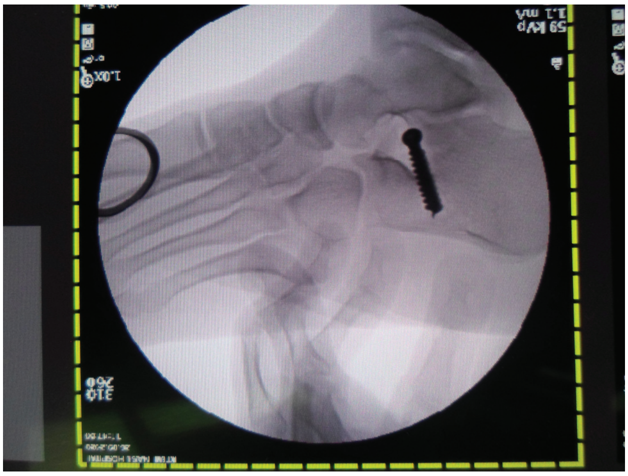
Clinical and functional outcomes of all patients were evaluated, before surgery, after surgery, and at 6 months after surgery (Fig. 4). Clinical evaluation was done using the American Orthopedic Foot and Ankle Society (AOFAS) Ankle–Hindfoot score [12], and hindfoot valgus angle [13]. Radiological

Figure 2



Drilling of calcaneus.

Figure 3



Calcaneal screw at position.

Figure 4

Photos of preoperative (a) and postoperative (b) correction of left foot.

assessment was done with calcaneal-pitch angles [6], Kite's angle [6], the talar-declination angle [6], lateral talar-first metatarsal angle (Meary's angle) [2], and talonavicular-coverage angle [14].

Almost all studies mentioned here are dealing with clinical evaluation of flatfoot-use AOFAS Ankle–Hindfoot score. There may be some difficulties in modification of American-style assessment with different cultures and nations [15]. Most of the authors used this score outside America, and did modification according to their patients. We used expression understood by patients and their parents. For example, we use different activities usually done by children and adolescents to assess the activities of the score such as football playing, shopping, and marketing. The 'block' expression of AOFAS score, which is not standard even within different states in America [15], was changed to 'next street walking' or 'towards end of the street walking.' The main target for assessment here, not to reflect the flatfoot affection, however, was to compare changes before and after the procedure.

Results

On the AOFAS Ankle–Hindfoot score (Table 1), there was progressive improvement with time (P<0.00001). The mean value after operation was 83.5±7.9. At the end of the study, it was 88.4±7.4. Clinical heel valgus (Table 1) showed significant improvement after surgery. The mean value after operation was 2.8±1.3 compared with 11.45±3.02 preoperatively.

Table 1 Clinical parameters

	Preoperative	Immediately postoperative	At the final follow-up
AOFAS Ankle–Hindfoot score	70.6	83.5 (7.9)	88.4 (7.4)
	4.8	*t* test 10.83	*t* test 13.92
Heel valgus	11.45 (3.0)	2.8 (1.3)	2.7 (1.3)
		t test 12.48	*t* test 12.38

AOFAS, American Orthopedic Foot and Ankle Society.

Table 2 Radiological parameters

	Preoperative	Immediately postoperative	At the final follow-up
Calcaneal-pitch angles	13.4 (1.1)	16.1 (1.6)	16.1 (1.4)
		t test 7.0	*t* test 7.5
Talar-declination angle	41.9 (5.0)	32.9 (4.7)	32.8 (4.5)
		t test 7.4	*t* test 7.6
Kite's angle	29.6 (3.1)	26.8 (2.5)	26.7 (2.7)
		t test 7.4	*t* test 7.6
Talonavicular-coverage angle	22.4 (5.4)	11.45 (6.0)	11.15 (5.7)
		t test 6.9	*t* test 7.5
Meary's angle	20.55 (6.9)	14.7 (4.73)	14.3 (4.73)
		t test 7.1	*t* test 7.7

Calcaneal-pitch angle (Table 2) showed significant changes (P<0.00001). This angle in addition to talar-declination angle reflects the status of medial arch. The talar-declination angle also showed significant changes (P<0.00001). The mean calcaneal-pitch angle (Table 2) after operation was 16.1±1.6 (15–18). That of talar-declination angle (Table 2) was 32.9±4.7 (25–35). There were nonsignificant changes at the end of the study of both angles. The Kite angle and talonavicular-coverage angles (Table 2), which reflect mainly coronal-plane movement, showed significant changes after operation (P<0.00001). The mean Kite angle immediately after operation was 26.8±2.5 (24–30). That of talonavicular-coverage angle immediately after operation was 11.45 ±6.03 (3–20). However, there were no significant changes at the end of the study.

Lateral Meary's talocalcaneal angle (Table 2) also showed improvement indicating correction of the sagittal plane. The mean postoperative value was 14.7±4.73 in comparison with 20.55±6.9 preoperatively. There was one (8.33%) female patient, who complained of pain at the site of surgery. However, there was no need for screw removal. No other complication was present.

Discussion

The merit of treatment for all flexible flatfeet remains equivocal. This ambiguity is partly due to the lack of a universally accepted classification system to allow specific measurement of improvement, together with a lack of high-level evidence for different treatment options [16].

Calcaneal stop and other surgeries that aim to restrict movement of subtalar joint without fusion are valid effective operations for treatment of idiopathic flatfoot in symptomatic children using a block to calcaneal eversion in a minimally invasive way. The surgery is reasonably straightforward without expensive instrumentation. It has less morbidity as well as a shorter postoperative course. It is a fast, minimally invasive, effective, and economical method for operative treatment of this condition [17].

These procedures were applied to limit subtalar-joint movement and improve the weight-bearing position of the foot, using a movement-blocking implant into the sinus tarsi. The calcaneo-stop procedure is simple, reliable, and minimally invasive for the treatment of pediatric flexible flatfoot, because it allows the alignment of the talus and calcaneus, restoring a proper foot arch. Operative correction of flexible flatfoot is performed with the aim of reducing symptoms rather than to correct the foot-shape deformity [6].

In our study of 20 feet, there was improvement of patient symptoms using AOFAS Ankle–Hindfoot score. In the study of Pavone *et al.* [6], of 410 feet, there was similar result using AOFAS Ankle–Hindfoot score. Although the difference between preoperative and postoperative was more than that of our study as the mean was 79.3±5.7 preoperatively and it was 97.3±4.5 at the end of their study. While in our study, it was 70.6±4.8 preoperatively and it was 88.4±7.4. However, both were significant *P* value less than 0.00001 and that of Pavone and colleagues was up to 3 years postoperatively.

Hamed [17], in his study, showed great difference between preoperative and postoperative using the same score. The mean value preoperatively was 56.76 (range: 48–73) to 95.29 (range: 90–100, $P<0.001$). The total number of feet in his study was 52.

Valgus heel with hyperpronation is the main cause of idiopathic flexible flatfoot in children. This position leads to planter and medial deviation of the talus. So the main target in treatment is to correct the heel valgus with the resultant hyperpronation [17]. In his study, Hamed [17] showed improvement of heel valgus with no recurrence after removal of screw. In our study, the mean value after operation was 2.8±1.3 compared with 11.45±3.02 preoperatively. Both studies showed significant improvement.

With radiological evaluation, there was also significant improvement in our study and the other studies. Our study in addition to that of Pavone and colleagues used Kite's angle, talar declination, and calcaneal-inclination angles. In addition to these angles, Pavone and colleagues used Costa-Bertani's angle.

Kite's angle changed from 31±0.82 to 24.91±1.77 in Pavone and colleagues study, while it changed from 29.6±3.1 to 26.7±2.7 in ours. Talar-declination angle changed from 43.31±5.32 to 29.96±2.3 in Pavone and colleagues study, while it changed from 41.9±5.0 to 32.8±4.5 in ours. Calcaneal-pitch angles changed from 12.54±1.38 to 16.74±1.16 in Pavone and colleagues study, while they changed from 13.4±1.1 to 16.1±1.4 in ours. All were statistically significant ($P<0.00001$).

In Hamed [17] study, he used calcaneal inclination in addition to Meary's angle, talohorizontal angles, talo-first metatarsal, and talonavicular-coverage angles. His study showed significant statistical improvement in all these angles. There was no statistically significant improvement in talocalcaneal and AP talocalcaneal angles, although there was improvement in angles.

Meary's angle and talonavicular coverage also showed significant improvement in our study. The improvement with time was not statistically significant.

Although there was improvement of all parameters, either clinical or radiological postoperatively, there were not significant changes with time in radiological parameters compared with clinical parameters.

Pavone and colleagues found that the mean value of AOFAS postoperatively changed from 96.4±4.5 (79–100) at 1-year postoperative to 97.3±4.5 (90–100) at 3-years postoperative. Other clinical parameters they used such as OxAFC, FADI, and FADI Sport showed similar changes.

In our study, the mean value of AOFAS changed from 83.5±7.9 (75–100) to 88.4±7.4 (80–100). In Hamed study, there were no chronological studies of his result at different intervals postoperative.

Even with nonsignificant changes of radiological studies with time, these clinical changes can reflect adaptation of the patients to the new foot position with proprioception accommodation and internal splint effect of the screw [18]. Pavone and colleagues found minor complications in 17 (12.5%) patients: five (3.7%) patients had pain at surgical scar, four (2.9%) had local symptoms at the incision, three (1.2%) had screw loosening, and four (2.9%) had superficial infections. In one (0.73%) case, screw breakage was reported.

Hamed found one (1.9%) case with overcorrection and the patient was readmitted to sunken the screw more inside calcaneus. Six (11.5%) children reported pain with prolonged walking.

In our study, there was one (5%) female patient who reported pain at the site of operation. However, no need for further intervention was required other than analgesia. It subsided with time.

Conclusion

Flexible flatfeet is a common condition in childhood. It may occur as an isolated disorder or as part of a broader syndrome, particularly if the individual has low muscle tone or ligamentous laxity, with joint hypermobility. There is lack of high-level evidence for different treatment options [16].

Failure of conservative management of symptomatic pes planovalgus is an indication for surgical management. The calcaneo-stop procedure is a simple and reliable method for the correction of severe pes planus in pediatrics pes planovalgus by aligning the talus and the calcaneus into normal position and maintaining the situation through proprioceptive stimuli arising from the sinus tarsi [17,18].

In our study, there was improvement of patients' symptoms and radiological parameters. In addition to that, calcaneal stop is a reversible procedure, not affecting further management and minimally invasive with minimal complication [6].

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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