Comparative Effectiveness of Calcaneal Stop Versus Subtalar Arthroereisis in Pediatric Flexible

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ABSTRACT

Background: Flexible flatfoot is a common pediatric foot deformity characterized by a collapsed medial arch and hindfoot valgus, leading to discomfort and functional limitations. While subtalar arthroereisis and the calcaneal stop technique are established surgical options for symptomatic cases, comparative effectiveness remains under investigation.

Patients and Methods: A prospective randomized study was conducted on 30 patients aged 5-15 years with symptomatic flexible flatfoot at Al-Ahrar Teaching Hospital from June 2019 to June 2021. Patients were randomly assigned to subtalar arthroereisis (n=15) or calcaneal stop procedure (n=15). Outcomes were assessed using the American Orthopedic Foot and Ankle Society (AOFAS) score, Visual Analogue Scale (VAS) for pain, and radiographic measures (Meary's angle, calcaneal pitch, calcaneal valgus, and talocalcaneal angles). Follow-up was conducted over 18 months.

Results: Both procedures showed significant improvements postoperatively, with mean AOFAS scores increasing from 71.53±3.81 preoperatively to 93.1±4.36 (p=0.001). Pain levels decreased substantially, with VAS scores reducing from 3.03±1.54 to 0.77±0.77 (p=0.001). Subtalar arthroereisis demonstrated a lower mean postoperative VAS score (0.47±0.52) compared to the calcaneal stop (1.1±0.88, p=0.03). The complication rate was low (10%), with minor issues reported in three patients.

Conclusion: Both subtalar arthroereisis and calcaneal stop procedures effectively improve clinical and radiographic outcomes in children with symptomatic flexible flatfoot. Subtalar arthroereisis may offer superior pain relief postoperatively, though both techniques show promising results.

Keywords: Pediatric flatfoot, Subtalar arthroereisis, Calcaneal stop, AOFAS score, Foot surgery.

INTRODUCTION

Flatfoot is a progressive foot condition that manifests over time, characterized by medial talar rotation, a reduced medial arch height, and forefoot abduction [1].

Genetically predisposed, flatfoot is common in infants, who are typically born with flat arches that generally develop during the first decade of life. Most cases of flexible flatfoot resolve spontaneously or remain asymptomatic [2]. However, certain cases lead to symptoms, such as pain along the medial arch, discomfort in the sinus tarsi, and leg pain. Flatfoot can impair an individual's ability to perform activities, resulting in altered gait mechanics. Many adult deformities stem from excessive pronation of the subtalar joint during the gait's propulsive phase [3].

Symptomatic flexible flatfoot often presents as pain in the feet and legs, particularly when standing or walking, challenges in mobility, and rapid fatigue during physical activities. Symptoms tend to worsen with age as the ability to maintain the medial longitudinal arch diminishes [4].

Flexible flatfoot is among the most frequently encountered foot deformities in children. It typically presents with a normal arch when weight-bearing, but the arch diminishes or disappears when the foot is not bearing weight. While flexible flatfoot may cause discomfort, it can also remain pain-free, referred to as asymptomatic or bilateral pes planus [3].

A variety of both non-surgical and surgical interventions have been described for managing symptomatic flexible flatfoot [5]. Extra-articular subtalar arthrodesis provides lasting correction and stability for symptomatic plano-valgus deformities, while triple arthrodesis is reserved for cases where previous interventions have failed. However, this approach may result in early-onset arthritis due to increased stress on adjacent, unfused joints [6].

The calcaneal stop technique uses a screw inserted through the sinus tarsi into the calcaneus, showing superior short-term outcomes in terms of pedographic, clinical, podoscopic, and radiological parameters [7,8].

Arthroereisis, derived from Greek terms meaning "joint elevation," involves placing a screw into the sinus tarsi region, positioned between the subtalar joint's anterior and posterior facets. This procedure helps realign the talus, restoring the longitudinal arch and mitigating flatfoot deformity [9].

Recent advances include the use of titanium screws with soft-threaded designs to reduce extrusion risks, replacing earlier materials like bone, polyethylene, and silastic. The technique requires no bone drilling or cement, making arthroereisis a minimally invasive and effective solution for addressing flatfoot symptoms [9].

The current study aimed to evaluate the effectiveness of subtalar arthroereisis versus the calcaneal stop technique in treating children and adolescents with flexible flatfoot, focusing on those aged 5 to 15 years.

PATIENTS AND METHODS

This prospective randomized study included 30 cases of flexible flatfoot presenting with discomfort during normal activities. The patients were randomly divided into two groups of 15 each, receiving either subtalar arthroereisis or calcaneal stop procedures. The study was conducted at Al-Ahrar Teaching Hospital from

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June 2019 to June 2021. The participants' ages ranged from 5 to 15 years, with a mean age of 9.5 years. There were 21 male and 9 female patients, all of whom were followed up for 18 months.

Inclusion Criteria

The study included patients aged between 5 and 15 years, with healthy control ankles (HCA) and no evidence of arthritis in the foot or ankle. Participants had to have flexible flatfoot that caused pain in their ankle and foot following normal activities and had not responded to conservative treatment for a duration exceeding six months.

Exclusion Criteria

Patients younger than 5 years or older than 15 years were excluded from the study, as well as those with stiff flatfoot. Additionally, patients with a history of diabetes, hypertension, post-traumatic conditions, or other deformities affecting limb alignment, such as genu valgus, were not eligible for inclusion.

Method of Evaluation

The evaluation of the patients included the American Orthopedic Foot and Ankle Society (AOFAS) score and pain assessment using DiMaggio and Miniño’s CLAD pain terms (VAS). Radiographic assessments included measurements of the calcaneal pitch angle and Meary's angle from standing lateral ankle views. Clinical evaluations also included photographic analysis of patients during walking.

Follow-Up

Patients completed AOFAS and VAS questionnaires monthly for the first six months, with data collection at two-month intervals during this period, and every six months thereafter. A follow-up period of 18 months was recommended to assess outcomes.

Assessment and Final Outcome Evaluation

Radiological measurements and patient data were compared with control values using parameters like Meary’s angle, calcaneal pitch angle, lateral talometatarsal angle, lateral talocalcaneal angle, and VAS scores. Pain levels were assessed before and after surgery, alongside evaluations of walking and standing abilities, changes in the medial longitudinal arch, subtalar joint dorsiflexion, patient and family satisfaction, shoe wear, and activity levels.

The Ankle-Hind Foot Score, a tool of the American Foot and Ankle Society, was used for evaluating the outcomes of ankle and hindfoot surgeries. Based on the work of **Kitaoka *et al.***, this system integrates patient-reported pain and functional ratings with the surgeon's assessment of sagittal plane motion, hindfoot alignment, and ankle stability [10]. The AOFAS scale allowed for detailed analysis of discomfort, activity limitations, assistance needs, stride length and pathology, ankle stability, sagittal and hindfoot motion, satisfaction levels, and any complications [11]. This approach combines subjective and objective assessments to provide a comprehensive view of the patient's clinical status.

Surgical Techniques

Subtalar Arthroereisis

Subtalar arthroereisis involves placing an implant screw into the sinus tarsi, between the posterior and anterior facets of the subtalar joint. The term "arthroereisis" originates from Greek, with "arthro" meaning joint and "ereisis" indicating lifting. The screw placement increases the vertical distance between the subtalar joints, raising the talus head's position to prevent misalignment with the calcaneus, restoring the longitudinal arch, and minimizing flatfoot deformity. Newer implants, such as titanium screws with low-profile threads, minimize the risk of extrusion. Unlike traditional methods, arthroereisis does not require bone drilling or cement, making it a minimally invasive treatment for patients with symptomatic flatfoot [9].

During the procedure, a small incision is made to access the sinus tarsi (Figure 1). The area is explored and manipulated using a probe to identify the subtalar joint's axis. A second small incision is made for placing the guide pin, ensuring proper positioning through fluoroscopic imaging. The implant is adjusted to a 1° to 2° valgus position, and the final placement is confirmed through X-ray imaging (Figures 2 and 3). Implants are positioned 1.5 cm from the lateral calcaneal wall for optimal screw purchase, allowing for proper eversion of the calcaneal subtalar joint to approximately 2–4 degrees. The wound is closed using multi-layer sutures, and a compression dressing is applied. Patients are allowed early weight-bearing 48 hours after surgery without the need for cast immobilization, and athletic activities are permitted 90 days post-operation.

Fig. 1 Incision for approach to sinus tarsi.

Fig. 2 lateral view showing the screw in sinus tarsi.

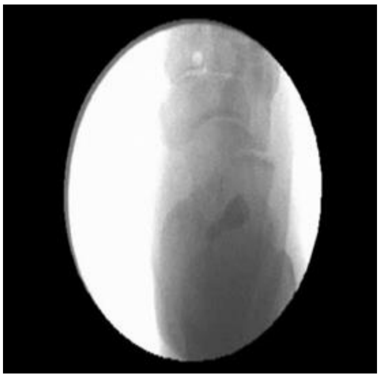

Fig. 3 Anteroposterior view showing the screw in sinus tarsi.

Calcaneal Stop Procedure

In the calcaneal stop procedure, a screw is placed into the sinus tarsi between the posterior and anterior subtalar joints. The screw adjusts the position of the talus head, restoring proper alignment with the calcaneus and correcting the plantar-flexed position of the talus seen in flexible pes planus [12,13]. This surgical method enhances the foot's longitudinal arch while stimulating sinus tarsi receptors, which help correct the subtalar joint's supination and support muscle and tendon activity. The procedure involves a 2-centimeter incision under the skin crease lines on the side opposite the sinus tarsi (Figure 4) [14].

Fig. 4 The minimally invasive skin incision at the level of the sinus tarsi was 2 cm.

An additional 2 cm incision is made on the sinus tarsi side. The periosteum of the anterior calcaneus is exposed, and a 2.75-millimeter drill hole is made, aligned with the talus's lateral process. A 3.5-millimeter divergent screw, along with a washer, is inserted vertically to maintain alignment and prevent medial rotation of the talus. The procedure is monitored using imaging to confirm accurate screw placement (Figure 5). The wound is then sutured, and a bivalve cast is applied. After two weeks, the cast is replaced with a below-the-elbow cast to facilitate movement. Full weight-bearing is allowed from the second to fourth week, and patients may resume sports activities after 12 weeks.

Fig. 5 Lateral view of the foot showing calcaneus-stop

Radiological Evaluation

Preoperative and postoperative standing anteroposterior and weight-bearing lateral radiographs were obtained for each patient. Measurements included the lateral calcaneal pitch, lateral talometatarsal, and anteroposterior talonavicular coverage angles to evaluate changes in foot alignment and assess the outcomes of the surgical interventions.

Ethical considerations:

The study was done after being accepted by the Research Ethics Committee, Al-Ahrar Teaching Hospital. All the caregivers of the patients provided written informed consents prior to their enrolment. The consent form explicitly outlined their agreement to participate in the study and for the publication of data, ensuring protection of their confidentiality and privacy. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical analysis

In the data analysis, the results of the quantitative variables were displayed as mean ± standard deviation (SD) and range, whilst the qualitative variables' details were examined using frequency and percentage. Data analysis of qualitative data was performed using the chi-square test (χ^2) and Fisher exact test by comparing proportions across the different research groups. In order to compare quantitative data from two different groups, we used the independent t test (t). The paired t-test was used for intra-group comparison to ensure that the difference from pre- to post-op evaluations was statistically significant. P-value was considered statistically significant if it was less than 0.05 and highly significant if it was less than 0.001.

In order to carry out the statistical analysis, SPSS, version 21, was utilised (SPSS Inc., Chicago Illinois. Company).

RESULTS

There was no significant difference between the 2 studied groups, regarding age and sex **(Table 1)**.

Table 1: Comparison between the two groups regarding demographic and clinical data.

Variable		Subtalar arthroereisis (n =15)	Calcaneal stop procedure (n =15)	Test	p
		Mean ±SD (range)	**Mean ±SD (range)**		
Age (years)		10.13 ± 3.64 (5 – 15)	8.87 ± 3.23 (5 – 14)	t= 1	0.3
		No. (%)	**No. (%)**		
Sex	**Male**	11 (73.3%)	10 (66.7%)	χ^2= 0.16	0.7
	Female	4 (26.7%)	5 (33.3%)		
Side affected	**Unilateral**	0 (0%)	0 (0%)	-	-
	Bilateral	15 (100%)	15 (100%)		

SD: Standard Deviation, n: Number, t: t-test value, χ^2: Chi-square, p: p-value.

The Meary's angle and the calcaneal pitch angle on the left showed a significant difference **(Table 2)**.

Table 2: Clinical features of the study groups (preoperative assessment)

Variable		Subtalar arthroereisis (n =15)	Calcaneal stop procedure (n =15)	Total (n= 30)	Test	p
		Mean ±SD	**Mean ±SD**	**Mean ±SD**		
AOFAS		70.87 ± 3.68	72.2 ± 3.94	**71.53 ± 3.81**	t= 0.96	0.35
VAS		3.33 ± 1.54	2.73 ± 1.53	**3.03 ± 1.54**	t=1.07	0.3
Meary's angle	Right	22.87 ± 7.62	20.4 ± 4.7	**21.63 ± 6.35**	t=1.07	0.3
	Left	24.53 ± 7.39	19.33 ± 2.89	**21.93 ± 6.11**	t=2.54	0.017*
Calcaneal pitch angle	Right	10.67 ± 3.37	12.6 ± 1.55	**11.63 ± 2.76**	t=2.02	0.053
	Left	10.47 ± 1.46	15 ± 2.85	**12.73 ± 3.2**	t=5.48	0.001**
Calcaneal valgus angle	Right	15.6 ± 6.03	14.67 ± 6	**15.13 ± 5.93**	t=0.43	0.67
	Left	15.87 ± 6.7	16.93 ± 7.13	**16.4 ± 6.82**	t=0.42	0.68
Talo-calcaneal angle	Right	35.13 ± 6.27	32.4 ± 5.62	**33.77 ± 6**	t=1.26	0.22
	Left	38.27 ± 7.12	32.73 ± 6.4	**35.5 ± 7.22**	t=2.24	0.033*

AOFAS: American Orthopedic Foot and Ankle Society, VAS: Visual Analog Scale, SD: Standard Deviation, n: Number, t: t-test value, *: Significant, **: Highly significant.

Postoperative improvements are noted in the means of all the parameters; AOFAS score, VAS, Meary's angle, the calcaneal pitch angle, the calcaneal valgus angle and the talocalcaneal **(Table 3)**.

Table 3: Preoperative and postoperative radiographic measures of the study patients.

Variable		Preoperative (n =30)	Postoperative (n =30)	Test	p
		Mean ±SD	**Mean ±SD**		
AOFAS		71.53 ± 3.81	93.1± 4.36	t= -25.5	0.001**
VAS		3.03 ± 1.54	0.77 ± 0.77	t=8.4	0.001**
Meary's angle	Right	21.63 ± 6.35	12.5 ± 3.9	t=10.8	0.001**
	Left	21.93 ± 6.11	12.63 ± 4.58	t=9.6	0.001**
Calcaneal pitch angle	Right	11.63 ± 2.76	19.2 ± 4.63	t= -8.7	0.001**
	Left	12.73 ± 3.2	23.2 ± 4.66	t= -9.8	0.001**
Calcaneal valgus angle	Right	15.13 ± 5.93	6.1 ± 2.64	t=9.1	0.001**
	Left	16.4 ± 6.82	5 ± 3.3	t=8.6	0.001**
Talo-calcaneal angle	Right	33.77 ± 6	24.57 ± 5.46	t=11.7	0.001**
	Left	35.5 ± 7.22	26.3 ± 5.55	t=7.4	0.001**

AOFAS: American Orthopedic Foot and Ankle Society, VAS: Visual Analog Scale, SD: Standard Deviation, p: p-value, t: t-test value, **: Highly significant.

The mean postoperative AOFAS score is indicating no significant difference. The mean VAS score was significantly lower in the subtalar arthroereisis group compared to in the calcaneal stop group. The calcaneal valgus angle showed a significant difference on the left side, with lower values in the subtalar arthroereisis group **(Table 4)**.

Table 4: Comparison between the two groups regarding postoperative radiographic measures

Variable		Subtalar arthroereisis (n =15) Mean ±SD	Calcaneal stop procedure (n =15) Mean ±SD	Test	p
AOFAS		94.2 ± 3.53	91.93 ± 4.92	t= 1.45	0.16
VAS		0.47 ± 0.52	1.1 ± 0.88	t= - 2.3	0.03*
Meary's angle	Right	12 ± 4.5	13 ± 3.25	t= - 0.7	0.5
	Left	11.93 ± 5.82	13.33 ± 2.91	t= - 0.8	0.4
Calcaneal pitch angle	Right	20.47 ± 4.75	17.93 ± 4.3	t= 1.5	0.14
	Left	22.87 ± 5.49	23.53 ± 3.81	t= - 0.4	0.7
Calcaneal valgus angle	Right	5.53 ± 3.23	6.6 ± 2.77	t= - 1.1	0.3*
	Left	3.33 ± 2.99	6.67 ± 2.77	t= - 3.2	0.004*
Talo-calcaneal angle	Right	26.13 ± 4.91	23 ± 5.69	t= 1.6	0.1
	Left	27.93 ± 5.2	24.67 ± 5.58	t= 1.7	0.1

AOFAS: American Orthopedic Foot and Ankle Society, VAS: Visual Analog Scale, SD: Standard Deviation, t: t-test value, *: Significant.

A total of 90% (27 out of 30) of patients did not experience complications following surgery. No statistically significant difference was noted in complication rates between the two groups **(Table 5)**.

Table 5: Postoperative complications

Variable	Subtalar arthroereisis (n =15) No. (%)	Calcaneal stop procedure (n =15) No. (%)	Total (n=30) No. (%)	Test	p
No	14 (93.3%)	13 (86.7%)	27 (90%)	FET= 2.8	1
Talar osteolysis	0 (0%)	1 (6.7%)	1 (3.3%)		
Subluxation of screw	1 (6.7%)	0 (0%)	1 (3.3%)		
aseptic loosening, Pain, Minute Peri screw Fracture.	0 (0%)	1 (6.7%)	1 (3.3%)		

n: Number., FET: Fisher's Exact Test .

DISCUSSION

In our study, the calcaneal valgus angle showed significant improvement after surgery. The average preoperative angle for the calcaneus stop procedure was 14.67° ± 6° on the right side and 16.93° ± 7.13° on the left side. Postoperative angles decreased to 6.6° ± 2.77° on the right and 6.67° ± 2.77° on the left. Previous researchers [15] observed a reduction in the mean resting heel valgus angle from 12.2° ± 4.48° preoperatively to 5.2° ± 3.28° during follow-up. Both the subtalar arthroereisis and calcaneus stop procedures showed notable postoperative improvements, with mean valgus angles of 6.1° ± 2.64° on the right and 5° ± 3.3° on the left (P = 0.001) in both procedures. Subtalar arthroereisis demonstrated a more substantial improvement, with a postoperative mean valgus angle of 3.33° ± 2.99° compared to 6.67° ± 2.77° for the calcaneus stop (P = 0.004).

The talocalcaneal angle also showed improvements. For arthroereisis, in one study, the preoperative angle averaged 35.13° ± 6.27° on the right side and 38.27° ± 7.12° on the left side, decreasing to 26.13° ± 4.91° on the right and 27.93° ± 5.2° on the left postoperatively (P = 0.001). The study also reported a similar trend, with preoperative angles of 29.06° on the right and 28.69° on the left, improving to 16.06° and 17.43° postoperatively [16]. For the calcaneus stop procedure, the average preoperative talocalcaneal angles of 32.4° ± 5.62° on the right and 32.73° ± 6.4° on the left improved to 24.67° ± 5.58° on the left and 23° ± 5.69° on the right (P = 0.001). The overall complication rate in the study was low at 10%, with minor issues occurring in 3 patients, including talar osteolysis (3.3%), screw subluxation (3.3%), and aseptic loosening (3.3%) [17].

In the current study, no significant difference in complication rates was found between the two procedures (P = 1). Complications from arthroereisis procedures can be divided into general complications and implant specific complications. The most common general complication reported was sinus tarsi pain. The most common implant specific complications are of implant misalignment or degradation. Sinus tarsi pain can be due to over correction, or its potential cause may be too large an implant, this should quickly resolve with implant removal. However, it is important to note that when an implant is not placed appropriately, a patient may eventually develop arthritis of the subtalar joint [18]

A study in 2012 [18] revealed a significantly variable complication rate of 30% to 40% for subtalar arthroereisis. Constant discomfort in the sinus tarsi, osteonecrosis, arthrosis of the subtalar joint, overcorrection, implant loosening or breaking are among these complications. Some of the most severe outcomes include rupture, incorrect fixation, and implant subluxation. The very first management of the complications is removal of the implant.

Another study [19] showed that the most common reason for sinus tarsi discomfort after arthroereisis is mechanical irritation to the bone and soft tissues caused by the implant. Also, an implant can cause sinus tarsi pain if the implant is not fixed properly or if an implant that is inadequate in size is implanted.

Also, other researchers [20,21] has demonstrated that removing the implant too soon does not change the foot's position, thereby preserving some degree of correction, and results in positive clinical outcomes.

A study in 2021 [21] stated that there were no intra-/postoperative complications related to neurovascular insult, delayed healing of wound, infection, or fracturing during their study. Out of all the issues affecting the implant, 17 out of 113 feet (15 percent) had primary or secondary dislocation, or implant fracture.

And a study in 2011 [9] reported that after three months of debridement and reinsertion with a lower size, as a result, the implant became loose and protruded from the body in one patient (3.3 percent). After implant loosening and extrusion three months after debridement and a smaller implant reinsertion, one patient (3.3 percent) experienced reactional synovitis.

Complications related to the calcaneus stop procedure in our study were reported in two cases as subluxation of screw, talar osteolysis, aseptic loosening, pain, and minute peri-screw fracture

A recent study [22], reported that the incidence of complications is quite low (0.07 percent). Just three patients experienced a mild problem. Out of all the patients, just one representing 0.02% of the total needed deformity treatment, had indicated widespread ligamentous laxity. A hidden screw, representing 0.02% of the total, was discovered after drilling into the distant cortex while treating one patient. Synovitis surrounding the screw head occurred in one patient (0.02%), necessitating removal of the screw.

Another study [20] found difficulties in 12% of cases, including 11 foot, 9 broken screws, and 2 lost screws. The reason why nine out of ten orthopedic evaluators rated the results as excellent or good is that the correction remained in seven out of nine feet where the screws broke, and the patients were satisfied overall. This is what five feet looked like. It was still feasible to fix the malformation, even if the screw is in the improper spot. There was no unscrewing and no lashing up of the fever. In two feet, the screw passed through the calcaneus's hollow (2 percent). Upon removal of the screws in six feet, or six percent of the youngsters, they complained of pain after bearing weight for extended periods of time; however, they reported lesser severity than before the operation.

Also, other researchers [8] reported no complications. In 83 percent of cases, the subtalar joint became painful and immobile in response to screw mobilisation. These individuals needed to have their implants reset and arthroereisis was performed with new screws. In 11.98% of our patients, we found minor problems occurring after surgery. Dressing the surgical wound well reduced the incidence of these local responses, which mostly occurred at the incision site and during the delayed reloading periods. Peroneal muscles stiffness was managed through physiotherapy which was later followed by retraining in walking as well as the strengthening of the involved muscles.

Research by our group confirms that, when the two methods are used meticulously to the specific signs of a pure flexible type of flat foot, it successfully fixes the deformity without any symptoms or components of the deformity coming back. To ensure the correction remains, it is essential to follow up with these youngsters for an extended period of time. Evidently, the outcome of the procedure met the expectations of both the patients and their parents, as all cases involving bilateral anomalies resulted in the other foot being surgically corrected.

The study's limitations include a small sample size of 30 patients, which may limit the generalizability of the results. The relatively short follow-up period of 18 months restricts the ability to assess long-term outcomes and potential complications. Additionally, the study was conducted at a single center, which may introduce institutional biases. Further, the lack of blinding could have influenced subjective assessments, such as pain scores. Future studies with larger, multicenter cohorts and longer follow-up periods are needed to validate these findings.

CONCLUSION

Calcaneus stop procedure is a worthy, valid, important, and secure technique to correct painful idiopathic flatfoot in children. It appears to be very promising if we factor the duration, methods' ease, the fabrication time, and the rate of complications that are related to the procedure. The implant that is used in this procedure is very cheap and economic. Minimal damage, no marked swelling postoperatively, time required for the operation, the ability to put weight on the leg early, and the possibility of further procedures involving soft tissues or bones are the advantages of this procedure.

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REFERENCES

1. **Arangio G, Reinert K, Salathe E (2004):** A biomechanical model of the effect of subtalar arthroereisis on the adult flexible flat foot. Clin Biomech., 19(8):847-52.

2. **Benedetti M, Ceccarelli F, Berti L *et al*. (2011):** Diagnosis of flexible flatfoot in children: a systematic clinical approach. Orthopedics, 34(2).
3. **Harris E, Vanore J, Thomas J *et al*. (2004):** Diagnosis and treatment of pediatric flatfoot. J Foot Ankle Surg., 43(6):341-73.
4. **Mosca V (1998):** The child's foot: principles of management. J Pediatr Orthop., 18(3):281-2.
5. **Baker J, Klein E, Weil L *et al*.** (2013): Retrospective analysis of the survivability of absorbable versus nonabsorbable subtalar joint arthroereisis implants. Foot Ankle Spec., 6(1):36-44.
6. **Sekiya J, Saltzman C (1997):** Long term follow-up of medial column fusion and tibialis anterior transposition for adolescent flatfoot deformity. Iowa Orthop J., 17:121.
7. **Kellermann P, Roth S, Gion K *et al*. (2011):** Calcaneo-stop procedure for paediatric flexible flatfoot. Arch Orthop Trauma Surg., 131(10):1363-7.
8. **Pavone V, Costarella L, Testa G *et al*. (2013):** Calcaneo-stop procedure in the treatment of the juvenile symptomatic flatfoot. J Foot Ankle Surg., 52(4):444-7.
9. **Metcalfe S, Bowling F, Reeves N (2011):** Subtalar joint arthroereisis in the management of pediatric flexible flatfoot: a critical review of the literature. Foot Ankle Int., 32(12):1127-39.
10. **Kitaoka H, Alexander I, Adelaar R *et al*. (1994):** Clinical rating systems for the ankle-hindfoot, midfoot, hallux, and lesser toes. Foot Ankle Int., 15(7):349-53.
11. **Rodrigues R, Masiero D, Mizusaki J *et al*. (2008):** Translation, cultural adaptation and validity of the American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Scale. Acta Ortopédica Bras., 16:107-11.
12. **Giannini S, Cadossi M, Mazzotti A *et al*. (2017):** Bioabsorbable calcaneo-stop implant for the treatment of flexible flatfoot: a retrospective cohort study at a minimum follow-up of 4 years. J Foot Ankle Surg., 56(4):776-82.
13. **Pfeiffer M, Kotz R, Ledl T *et al*. (2006):** Prevalence of flat foot in preschool-aged children. Pediatrics, 118(2):634-9.
14. **Forriol F, Pascual J (1990):** Footprint analysis between three and seventeen years of age. Foot Ankle, 11(2):101-4.
15. **Jerosch J, Schunck J, Abdel-Aziz H (2009):** The stop screw technique—a simple and reliable method in treating flexible flatfoot in children. Foot Ankle Surg., 15(4):174-8.
16. **Ruiz-Picazo D, Jiménez-Ortega P, Doñate-Pérez F *et al*. (2019):** Radiographic and functional results following subtalar arthroereisis in pediatric flexible flatfoot. Adv Orthop., 2019: 5061934.
17. **Ahmed M, Fayed A, Mahmoud A *et al*. (2018):** Evaluation of results of calcaneo-stop procedure in treatment of pediatric flexible flatfoot. Med J Cairo Univ., 86:333-9.
18. **van Ooij B, Vos CJS, Saouti R (2012):** Arthroereisis of the subtalar joint: an uncommon complication and literature review. J Foot Ankle Surg., 51(1):114-7.
19. **Needleman R (2005):** Current topic review: subtalar arthroereisis for the correction of flexible flatfoot. Foot Ankle Int., 26(4):336-46.
20. **Roth S, Sestan B, Tudor A *et al*. (2007):** Minimally invasive calcaneo-stop method for idiopathic, flexible pes planovalgus in children. Foot Ankle Int., 28(9):991-5.
21. **Vogt B, Toporowski G, Gosheger G *et al*. (2021):** Subtalar arthroereisis for flexible flatfoot in children—clinical, radiographic and pedobarographic outcome comparing three different methods. Children, 8(5):359.
22. **Elmarghany M, Abd El-Ghaffar T, Elgeushy A *et al*. (2020):** Is subtalar extra articular screw arthroereisis (SESA) reducing pain and restoring medial longitudinal arch in children with flexible flat foot? J Orthop., 20:147-53.