Satisfactory outcomes of post-operative subtalar extra-articular arthroereisis in juvenile flexible flat foot

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ABSTRACT

الأهداف: ستحلل دراستنا مقياس نتائج فاعلية زراعة قطعة مفصلية تحت مفصل الكاحل لتصحيح القدم المسطحة المرنة للأطفال ورضا المريض/ الوالدين، فيما يتعلق بشكل القدم وآلام القدم والقدرة على المشي والقدرة على القفز و إرتداء الأحذية.

المنهجية: أجريت دراستنا بإستخدام تقصي مقطعي تراجعي وذلك من خلال استبيان إلكتروني لتقييم رضا المرضى بعد الجراحة في ثلاث مستشفيات؛ مستشفى جامعة الملك خالد، مدينة الأمير سلطان بن عبد العزيز الإنسانية، ومستشفى دله، بين عامي 2014-2021.

النتائج: ضمت دراستنا 65 مريضاً. خضع 86.1% لعملية في كلا القدمين، كانت من أهم الجوانب التي لاحظ المرضى فيها التحسن الأكبر هي شكل القدم بنسبة (90.8%) والألم بنسبة (81.5%) والقدرة على المشي بنسبة (76.9%).

الخلاصة: تم إجراء العديد من الدراسات التي تسلط الضوء على التقنية الجراحية ومضاعفات الإجراء. ومع ذلك، فقد تم إجراء عدد محدود من الدراسات لتقييم رضا المريض عن الإجراء، خاصة في المملكة العربية السعودية، حيث يعتبر الإجراء جديدًا نسبيًا في المنطقة مع بيانات غير كافية عنه. لذلك، تعتبر هذه الدراسة واحدة من الدراسات القليلة حول مقياس نتائج فاعلية زراعة قطعة مفصلية تحت مفصل الكاحل لتصحيح القدم المسطحة المرنة للأطفال.

Objectives: To analyze the surgical outcomes of subtalar extra-articular arthroereisis and the patient/parent satisfaction regarding the foot's shape, foot pain, ability to walk, ability to jump, and shoe wear.

Methods: Our retrospective cross-sectional study was carried out through an online-based questionnaire to assess patient satisfaction postoperatively at 3 hospitals (King Khalid University Hospital, Sultan bin Abdulaziz Humanitarian City, and Dallah Hospital, Riyadh, Saudi Arabia) between the years 2014-2021.

Results: A total of 65 patients participated in our study. Approximately 86.1% of them had the operation bilaterally. The most important aspects where patients noticed the most improvement were the foot's shape (90.8%), pain (81.5%), and ability to walk (76.9%).

Conclusion: Several studies have been carried out highlighting the surgical technique and complications of the procedure. However, a limited number of studies have been carried out to assess patient satisfaction with the procedure, especially in Saudi Arabia, as the procedure is considered relatively new in the region with insufficient data regarding it. Therefore, this study is considered one of the few articles regarding subtalar extra-articular arthroereisis in the region.

Keywords: arthroereisis, flatfoot, sinus tarsi implant, patient satisfaction, surveys and questionnaires

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Flexible flatfoot (FFF) is a common malformation that can affect both children and adults. It is distinguished by a diminished or collapsed arch, excessive heel eversion while bearing weight, and forefoot abduction brought on by subtalar joint eversion.[1]

The majority of patients with flatfoot are asymptomatic, and it occasionally resolves on its own in certain cases. Additionally, tightness in the gastrocnemius or Achilles tendon, peroneus spasms, and medial column instability are frequently noted. Flexible flatfoot treatments in children remain debatable.[2] Orthotics and conservative management are first-line

treatments of FFF, but are sometimes inadequate; hence, surgical intervention is recommended for individuals who continue to complain on discomfort, loss of function, and easy fatiguability, or those who have deformity progression despite receiving conservative care.[3-6] Several surgical procedures for flatfoot include tendon lengthening and transfer, osteotomies, subtalar arthroereisis, and arthrodesis.[7] The subtalar arthroereisis procedure is a valid treatment option that refers to placing an artificial implant (these can include multiple types of implants including Kalix or Maxwell-Brancheau [MBA] implants) in the sinus tarsi to restrict excessive eversion of the subtalar joint and is often carried out in conjunction with Achilles tendon lengthening or gastrocnemius recession.[8,9] To the best of our knowledge, the effects of subtalar arthroereisis on the flatfoot were not reported sufficiently due to the limited studies published regarding this treatment option in Saudi Arabia. Therefore, the purpose of this study is to evaluate the outcomes of treatment on postoperative pain, function, satisfaction, and shoe wear in our population in Riyadh, Saudi Arabia.

Methods. We carried out a retrospective cross-sectional study of patients with FFF treated by subtalar extra-articular arthroereisis with Achilles tendon lengthening or gastrocnemius recession. All surgeries were carried out by our senior consultant pediatric orthopedic surgeon or under his supervision in 3 hospitals: King Khalid University Hospital, Sultan bin Abdulaziz Humanitarian City, and Dallah Hospital, Riyadh, Saudi Arabia, between 2014-2021. Consecutive sampling was used to collect our data.

The study included 65 juveniles with 121 symptomatic FFF (59 left feet and 62 right feet). There were 31 males and 34 females, with a mean age of 12.03 (range: 4-18) years. Among them, 56 patients were treated with bilateral flatfoot operations (86.1%). The mean operation time was 40.3 minutes per case (range: 25-50 minutes), and the mean perioperative blood loss was 5.2 mL per case (range: 2-24 mL). All 65 juveniles were followed up for a mean of 33.6 months (range: 4-89).

All patients diagnosed with FFF who failed conservative management and were between ages 4-18 years at the time of surgery, were included. All patients with rigid flatfoot or with prior surgical intervention were excluded. Verbal consents were obtained from all involved subjects or their guardians.

This study was approved by King Saud University Institutional Review Board (approval no.: E-22-6905).

We inserted a special implant (Kalix or MBA) into the tarsal canal that provides stability to the subtalar joint and prevents eversion. All procedures were carried out under general anesthesia as in-patient operations. All patients were in supine position with the ipsilateral hip lifted and draping was carried out. The first step to fulfill the procedure includes Achilles tendon lengthening or gastrocnemius muscle recession before the arthroreisis, then a 1-2 cm oblique skin incision is made over the sinus tarsi (Figure 1), and blunt subcutaneous dissection was carried out to expose the sinus tarsi. Then, a guide pin is inserted through the sinus tarsi and exits through a small incision medially. Trial implants were inserted until the appropriate size is determined. We chose the smallest implant that corrected the deformity and remained stable during the range of motion and examined with fluoroscopy. The skin was closed in layers, and a sterile dressing with a below-knee walking cast was applied. Postoperative measures include supporting devices such as a walking cast or brace to assist in walking for 6 weeks, and the patient was allowed for full weight bearing on the affected foot as tolerated.

Based on the online-based questionnaire administrated during the clinical interview, clinical variables, such as age, gender, pain, recurrence, satisfaction, complications, functional range of motion,

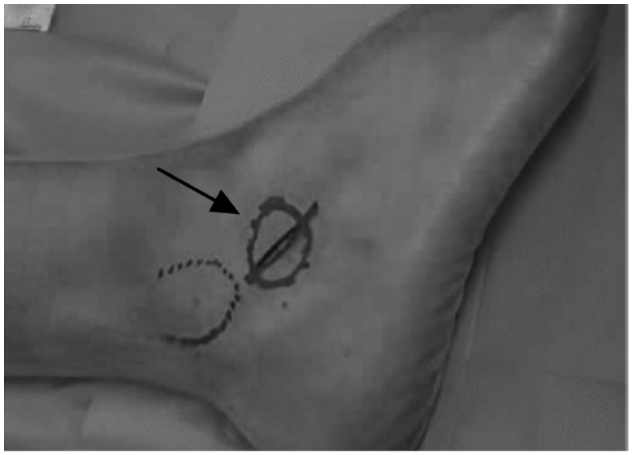

Figure 1 - The minimally invasive skin incision at the level of the sinus tarsi is approximately 2 cm.

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and shoe wear, were analyzed. Results were categorized into significant, partial, or no improvement according to the patients' impression when comparing the preoperative state with the postoperative outcome.

Figure 2 illustrates clinical photographs obtained before and after the subtalar arthroereisis procedure in a randomly selected patient.

Figure 3 exhibits a clinical photograph obtained during a follow-up visit between 2 scheduled operations for the correction of each foot in a randomly selected patient.

Statistical analysis. Data were analyzed using the Statistical Package for the Social Sciences, version 22.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD), and categorical variables were expressed as percentages. The Chi-squared test was used for categorical variables. A *p*-value of <0.05 was considered significant.

Figure 2 - Preoperative (left) and postoperative (right) anterior view showing realignment and correction of flatfoot deformity.

Figure 3 - Comparison of right foot which shows correction of hindfoot eversion and collapse of the arch postoperatively, in comparison to the left foot prior to operation.

Table 1 - Characteristics of the patients (N=65).

Variables	n (%)
Age, mean	12.03
On which foot was the operation carried out?	
Right	6 (9.2)
Left	3 (4.6)
Both feet	56 (86.1)
How much improvement was recognized in the shape of the foot, comparing before and after the operation?	
Significant improvement	39 (60.0)
Partial improvement	20 (30.8)
No improvement	6 (9.2)
How much improvement was noticed in terms of foot pain, comparing before and after the operation?	
Significant improvement	27 (41.5)
Partial improvement	26 (40.0)
No change in pain	6 (9.2)
Increase in pain	6 (9.2)
How much improvement was noticed in the ability to walk, comparing before and after the operation?	
Ability to walk long distances	27 (41.5)
Ability to walk short distances	23 (35.4)
Unable to walk	15 (23.1)
How much improvement was noticed in the ability to jump and play, comparing before and after the operation?	
Significant improvement	23 (35.4)
Partial improvement	19 (29.2)
Unable to jump and play	23 (35.4)
How much improvement was noticed in the ability to wear shoes, comparing before and after the operation?	
Significant improvement	36 (55.4)
Partial improvement	14 (21.5)
Unable to wear shoes	15 (23.1)
Was the metal fragment extracted after the procedure? (any duration postoperative)	
Yes	4 (6.1)
No	61 (93.8)
If the answer to the previous question was yes, which foot was the metal fragment removed from?	
Right	1 (25.0)
Left	2 (50.0)
Both feet	1 (25.0)
What was the duration before removal of the metal fragment?	
<1 year	1 (25.0)
1-3 years	2 (50.0)
>3 years	1 (25.0)

Values are presented as numbers and precentages (%).

Results. The study included 65 patients in all, with a mean age of 12.03±3.75 years. Data are shown in Table 1. The majority (86.1%) of patients were operated on bilaterally (right and left), and the vast majority (90.8%) have noted postoperative improvement in the shape of the foot, whether significant (60%) or partial (30.8%). In terms of pain, 81.5% have reported an improvement in foot pain post-surgery (41.5% significant and 40% partial improvement).

Approximately 76.9% reported improvement in the ability to walk long or short distances. The capacity to jump and play significantly improved in 35.4% of patients postoperatively, whereas 35.4% were unable to do so. More than half (55.4%) of patients stated that being able to wear shoes postoperatively had significantly improved. Only 4 (6.1%) had the metal implant removed after surgery, and 2 of them did so within the first 3 years. When data were analyzed according to the patient's age group (Table 2), we found no significant differences in any of the studied characteristics (p>0.05). However, significant clinical improvement was higher in the younger age group (<12 years) compared to those aged ≥12 years in foot shape (61.5% vs. 59.0%), foot pain (46.1% vs. 38.5%), ability to jump and play (46.1% vs. 28.2%), and ability to wear shoes (57.7% vs. 53.8%).

When characteristics were studied according to the operated foot, either unilateral or bilateral (Table 3), we found statistically significant results when 2 feet were operated on, showing that improvement in the shape of the foot was significantly (p=0.019) higher than those who were operated on one foot only, with significant improvement of (60.7% vs. 55.6%) and partial improvement of (33.9% vs. 11.1%). Other characteristics in Table 3 were insignificant.

Table 2 - Characteristics of the patients by age group.

Variables	<12 years (n=26)	≥12 years (n=39)	*P*-values
On which foot was the operation carried out?			
Right	3 (11.5)	3 (7.7)	
Left	0 (0.0)	3 (7.7)	0.32
Both feet	23 (88.5)	33 (84.6)	
How much improvement was recognized in the shape of the foot, comparing before and after the operation?			
Significant improvement	16 (61.5)	23 (59.0)	
Partial improvement	10 (38.5)	10 (25.6)	0.088
No improvement	0 (0.0)	6 (15.4)	
How much improvement was noticed in terms of foot pain, comparing before and after the operation?			
Significant improvement	12 (46.1)	15 (38.5)	
Partial improvement	12 (46.1)	14 (35.9)	0.192
No change in pain	0 (0.0)	6 (15.4)	
Increase in pain	2 (7.7)	4 (10.3)	
How much improvement was noticed in the ability to walk, comparing before and after the operation?			
Ability to walk long distances	10 (38.5)	17 (43.6)	
Ability to walk short distances	11 (42.3)	12 (30.8)	0.618
Unable to walk	5 (19.2)	10 (25.6)	
How much improvement was noticed in the ability to jump and play, comparing before and after the operation?			
Significant improvement	12 (46.1)	11 (28.2)	
Partial improvement	6 (23.1)	13 (33.3)	0.326
Unable to jump and play	8 (30.8)	15 (38.5)	
How much improvement was noticed in the ability to wear shoes, comparing before and after the operation?			
Significant improvement	15 (57.7)	21 (53.8)	
Partial improvement	5 (19.2)	9 (23.1)	0.928
Unable to wear shoes	6 (23.1)	9 (23.1)	
Was the metal fragment extracted after the procedure? (any duration postoperative)			
Yes	2 (7.7)	2 (5.1)	0.673
No	24 (92.3)	37 (94.9)	
If the answer to the previous question was yes, which foot was the metal fragment removed from?			
Right	0 (0.0)	1 (50.0)	
Left	1 (50.0)	1 (50.0)	0.368
Both feet	1 (50.0)	0 (0.0)	
What was the duration before removal of the metal fragment?			
<1 year	0 (0.0)	1 (50.0)	
1-3 years	2 (100)	0 (0.0)	0.135
>3 years	0 (0.0)	1 (50.0)	

Values are presented as numbers and precentages (%).

Discussion. Clinical assessment and findings of the distinctive radiographic anomalies are usually used to diagnose FFF.[1] Despite the ease of making a diagnosis, therapeutic principles and surgical indications are still controversial.[2] Some experts recommended that only functioning flatfeet should be treated.[3] However, distinguishing between morphological and functional flatfoot is not always easy; more often than not, surgical therapy is needed when the patient complains of pain, discomfort, early weariness, and limits in routine activities.[4,5] The largest impact of FFF on patients is the impact on quality of life, as when patients are symptomatic it prevents them from performing their daily activities, this is especially important in the pediatric age group, as walking, running, and playing are integral factors in childhood. Arthroereisis is one of the most commonly carried out procedures for the treatment of FFF. Therefore, this study aimed to assess and analyze the outcomes of post-subtalar arthroereisis procedure by improving pain, function, satisfaction, and shoe wear in Riyadh, Saudi Arabia. Results of the current study revealed a significant clinical improvement in foot shape, pain, ability to jump and play, ability to walk long distances, and ability to wear shoes. Our results are also in line with a previous similar study among juveniles showing subtalar joint arthroereisis can be beneficial in the treatment of FFF.[6] When compared to operations such as midfoot or hindfoot osteotomies or arthrodesis, arthoereisis has reduced morbidity for patients peri-operatively. The risk of nonunion and immobilization could occur, and arthroereisis is considered a simple surgical procedure.[6] Similarly, when considering arthroereisis, all authors reporting results on different cohorts (noncomparative studies) concluded that this minimally invasive procedure was an 'optimal' technique for the correction of FFF in children and adults, providing clinical and radiological satisfactory outcomes.[7-9] A recently published review by

Table 3 - Characteristics of the patients by foot.

Variables	One foot (right or left), n=9	Two feet (n=56)	*P*-values
On which foot was the operation carried out?			
Significant improvement	5 (55.6)	34 (60.7)	
Partial improvement	1 (11.1)	19 (33.9)	0.019*
No improvement	3 (33.3)	3 (5.4)	
How much improvement was recognized in the shape of the foot, comparing before and after the operation?			
Significant improvement	4 (44.4)	23 (41.1)	
Partial improvement	4 (44.4)	22 (39.3)	0.783
No change in pain	1 (11.1)	5 (8.9)	
Increase in pain	0 (0.0)	6 (10.7)	
How much improvement was noticed in the ability to walk, comparing before and after the operation?			
Ability to walk long distances	2 (22.2)	25 (44.6)	
Ability to walk long distances	5 (55.6)	18 (32.1)	0.343
Unable to walk	2 (22.2)	13 (23.2)	
How much improvement was noticed in the ability to jump and play, comparing before and after the operation?			
Significant improvement	1 (11.1)	22 (39.3)	
Partial improvement	3 (33.3)	16 (28.6)	0.223
Unable to jump and play	5 (55.6)	18 (32.1)	
How much improvement was noticed in the ability to wear shoes, comparing before and after the operation?			
Significant improvement	4 (44.4)	32 (57.1)	
Partial improvement	1 (11.1)	13 (23.2)	0.244
Unable to wear shoes	4 (44.4)	11 (19.6)	
Was the metal fragment extracted after the procedure? (any duration postoperative)			
Yes	0 (0.0)	4 (7.1)	0.408
No	9 (100)	52 (92.9)	
If the answer to the previous question was yes, which foot was the metal fragment removed from?			
Right	0 (0.0)	1 (25.0)	
Left	0 (0.0)	2 (50.0)	
Both feet	0 (0.0)	1 (25.0)	
What was the duration before removal of the metal fragment?			
<1 year	0 (0.0)	1 (25.0)	
1-3 years	0 (0.0)	2 (50.0)	
>3 years	0 (0.0)	1 (25.0)	

Values are presented as numbers and precentages (%).

Tan et al[10] examined the usage of arthroereisis in pes planus and concluded that arthroereisis was efficient in alleviating symptoms and deformities, a finding in agreement with our study results. Previous studies also reported satisfactory results that were comparable to those of the current research. Following the surgery in an adult population, Voegeli et al[11] discovered that 74% of patients were entirely happy or had only minor limits, such as discomfort or impairments in everyday life. Metcalfe et al[12] observed patient satisfaction percentages ranging from 79-100% in pediatrics. Brancheau et al[13] carried out a study using a patient questionnaire to assess MBA screw arthroereisis in adolescents and adults with symptomatic flexible flatfeet. This was a self-created questionnaire demonstrating that 95% of patients experienced alleviation from their concerns following therapy. Furthermore, 83% of patients reported no daily discomfort, and 62% participated in sports at a greater level.

In contrast to the current study findings which showed no statistically significant association between the procedure outcome and the patient's age, Kubo et al[14] found that age at the time of surgery appears to be a key factor affecting the outcome, with patients ages between 9-12 years considered the optimum. Younger individuals are at a higher risk of recurrence, whereas older patients have less effective results, most likely due to the foot's limited reconstruction ability.[14]

Study limitations. The number of patients in our study was limited due to the fact that only patients operated on by one senior consultant in the 3 hospitals were involved in our study. The follow-up duration also varied due to the same reasoning.

We recommend a multi-center study that assesses the satisfaction of patients and parents for subtalar extra-articular arthroereisis. In addition, we recommend a multi-center study that applies subjective measures such as radiographic imaging to assess postoperative outcomes.

In conclusion, FFF is a common condition with multiple treatment options, surgical management is a valid option, especially for cases where conservative management has failed. Subtalar extra-articular arthroereisis is one of the common procedures for the treatment of FFF, and it has shown promising results. Our results concluded that the procedure had satisfactory outcomes postoperatively specifically in regard to the shape of the foot and pain.

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References

1. Staheli LT. Evaluation of planovalgus foot deformities with special reference to the natural history. *J Am Podiatr Med Assoc* 1987; 77: 2-6.
2. Kelikian A, Mosca V, Schoenhaus HD, Winson I, Weil L Jr. When to operate on pediatric flatfoot. *Foot Ankle Spec* 2011; 4: 112-119.
3. Benedetti MG, Ceccarelli F, Berti L, Luciani D, Catani F, Boschi M, et al. Diagnosis of flexible flatfoot in children: a systematic clinical approach. *Orthopedics* 2011; 34: 94.
4. Giannini BS, Ceccarelli F, Benedetti MG, Catani F, Faldini C. Surgical treatment of flexible flatfoot in children a 4-year follow-up study. *J Bone Joint Surg Am* 2001; 83-A: 73-79.
5. Needleman RL. Current topic review: subtalar arthroereisis for the correction of flexible flatfoot. *Foot Ankle Int* 2005; 26: 336-346.
6. Zaret DI, Myerson MS. Arthroerisis of the subtalar joint. *Foot Ankle Clin* 2003; 8: 605-617.
7. Kellermann P, Roth S, Gion K, Boda K, Tóth K. Calcaneo-stop procedure for paediatric flexible flatfoot. *Arch Orthop Trauma Surg* 2011; 131: 1363-1367.
8. 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.
9. Viladot Voegeli A, Fontecilla Cornejo N, Serrá Sandoval JA, Alvarez Goenaga F, Viladot Pericé R. Results of subtalar arthroereisis for posterior tibial tendon dysfunction stage IIA1. Based on 35 patients. *Foot Ankle Surg* 2018; 24: 28-33.
10. Tan JHI, Tan SHS, Lim AKS, Hui JH. The outcomes of subtalar arthroereisis in pes planus: a systemic review and meta-analysis. *Arch Orthop Trauma Surg* 2021; 141: 761-773.
11. Roye DP Jr, Raimondo RA. Surgical treatment of the child's and adolescent's flexible flatfoot. *Clin Podiatr Med Surg* 2000; 17: 515-530.
12. Ozan F, Doğar F, Gençer K, Koyuncu Ş, Vatansever F, Duygulu F, et al. Symptomatic flexible flatfoot in adults: subtalar arthroereisis. *Ther Clin Risk Manag* 2015; 11: 1597-1602.
13. Brancheau SP, Walker KM, Northcutt DR. An analysis of outcomes after use of the Maxwell-Brancheau arthroereisis implant. *J Foot Ankle Surg* 2012; 51: 3-8.
14. Kubo H, Lipp C, Hufeland M, Ruppert M, Westhoff B, Krauspe R, et al. Outcome after subtalar screw arthroereisis in children with flexible flatfoot depends on time of treatment: midterm results of 95 cases. *J Orthop Sci* 2020; 25: 497-502.