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Case Report

Imaging findings of arthroereisis in planovalgus feet

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ABSTRACT

Arthroereisis is a rare and disputed procedure, where an implant screw is inserted into the sinus tarsi to treat flatfoot deformity. Weight-bearing radiographs are the most essential examinations to assess the correct localization and related measurements. Hardware loosening is the most common complication seen as localized lucency and as dislocation of the implant. Computed tomography yields superior resolution with reconstruction capabilities. On magnetic resonance imaging, the implant appears as a dark signal focus on T1 and T2-weighted images with a hyperintense T2-signal rim. As the data on the imaging of arthroereisis are scarce, we aimed here to review the typical imaging findings.

Introduction

Flexible flatfoot is a common condition in children and adults [1]. However, since no precise definition for the flexible flatfoot exists, the prevalence has not been documented in the literature [2]. In children, pathologic flexible flatfoot has been shown to have an incidence of 2.7%-4% [3–5]. Typically, flexible flatfoot is characterized by hindfoot valgus, talar adduction with plantar flexion, longitudinal medial-arch collapse, pes planus, and dorsolateral forefoot subluxation [6]. The treatment of symptomatic flatfoot in mainly conservative, but in some cases, surgical intervention is suggested [1,6]. Arthroereisis (derived from Greek *arthro-* meaning *joint* and *ereisis* meaning *lifting up*) is a procedure in which an implant screw is inserted between the posterior and anterior subtalar joints inside the sinus tarsi. The implantation of the screw expands the subtalar joint vertically, elevating the head of the talus which realigns the longitudinal arch of the foot and subsequently reduces the flatfoot deformity [7]. A number of implants have been used including bone, a polyethylene disk, silastic, a vitallium staple, and now more recently a titanium screw with

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soft-threaded design to resist extrusion. No bone drilling is necessary, and no cement is used, thus making arthroereisis a feasible minimally invasive procedure to treat symptomatic flatfoot [7].

Since the literature on the imaging of the arthroereisis is scarce, we propose to introduce to the radiologist the imaging appearances of subtalar arthroereisis in severe flatfoot and cases of complications of the inserted hardware. We recommend obtaining weight-bearing radiographs and vigilance in detecting hardware loosening after arthroereisis surgery.

The imaging findings of arthroereisis on radiographs

Weight-bearing lateral radiographs are essential to illustrate the medial longitudinal arch of the foot. In addition, anteroposterior weight-bearing radiographs allow visualization of the subtalar joint space. Both radiographic techniques are helpful to evaluate and determine the degree of flatfoot deformity, the postsurgical location of the implanted hardware, and the correction of anatomic alignment of the foot. Typical measurements used to evaluate the flatfoot deformity include calcaneal pitch angle, Meary's angle and lateral talocalcaneal angle (on the lateral view), and talonavicular coverage angle and talo-first metatarsal angle (on the anteroposterior view) [8] (Fig. 1).

On lateral radiographs, the radiodense screw can be readily detected in the sinus tarsi. The alignment of the implant should be such that the screw points to the subtalar joint and that the tip of the screw is located within the subtalar joint. On the oblique anteroposterior radiographs, the implant is ideally located on the anterolateral corner of calcaneus pointing slightly posterior into the subtalar joint. The implant should point about 15° off the perpendicular to the sagittal plane going from anterolateral to posteromedial. Furthermore, the implant should not be medial to the midline of the talar neck. The lateral edge of the implant should be at or just medial to the lateral side of the talus. On the anteroposterior view, the leading edge of the implant should bisect the talus or sit within the middle third of the talus. Figure 1 shows examples of optimal localization of the arthroereisis implant on lateral and oblique anteroposterior radiographs.

The most common complication of arthroereisis is the loosening of the hardware, which is seen as lucency surrounding the implant. Also, migration of the implant from the subtalar joint is occasionally observed as a complication of arthroereisis. Figures 2 and 3 depict loosening and migration, respectively, of the subtalar implant as seen on radiographs.

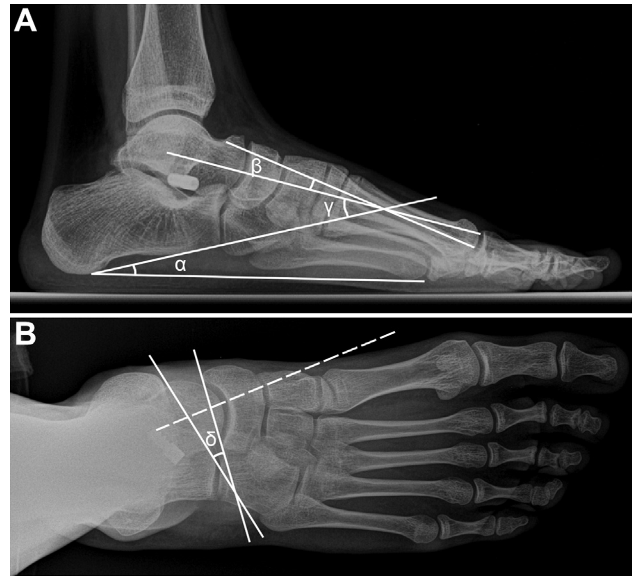

Fig. 1 – Case 1. Lateral (A) and anteroposterior (B) weight-bearing radiographs of a 13-year-old girl after arthroereisis procedure. Lateral (A) and anteroposterior (B) views show the optimal localization of the arthroereisis implant in the sinus tarsi in the subtalar joint between the talus and calcaneus. Measurements used to evaluate the flatfoot deformity include calcaneal pitch angle (α), Meary's angle (β), and lateral talocalcaneal angle (γ) on lateral view (A), and talonavicular coverage angle (δ) and talo-first metatarsal angle (dashed line) on anteroposterior view (B). Calcaneal pitch angle (α) is formed by the horizontal line and a line from the base of heel and inferior cortex of calcaneus, and less than 20° is considered to represent pes planus. Meary's angle (β) is the angle between the lines from the centers of longitudinal axes of the talus and the first metatarsal. More than 4° is considered as pes planus. Lateral talocalcaneal angle (γ) is the angle formed by the intersection of the line bisecting the talus with the line along the lower border of the calcaneus. An angle over 45° indicates hindfoot valgus, a component of pes planus. A line connecting the edges of the articular surface of the talus, and a line connecting the edges of the articular surface of the navicular forms the talonavicular coverage angle (δ), and greater than 7° indicates lateral talar subluxation. Talo-first metatarsal angle (dashed line) is formed by drawing a line through the midaxis of the talus; if this line is angled medial to the first metatarsal, it indicates pes planus.

Computed tomography and magnetic resonance imaging appearance of subtalar arthroereisis

A limitation of the computed tomography (CT) and magnetic resonance imaging (MRI) of the foot is that they are acquired in a non–weight-bearing position. In addition to radiographs, CT provides superior detection of the arthroereisis implant. With thin slices and multiplanar reconstruction capabilities, the localization and possible complications of the arthroereisis can easily detected. Figure 4 demonstrates an ideally located subtalar implant in the sinus tarsi on CT in axial, coronal, and sagittal planes with 3-dimensional reconstruction.

Compared to CT and radiographs, MRI provides superior resolution of the soft tissues. Also, the anatomy of the sinus tarsi can be evaluated more easily on MRI. Typically, the axial

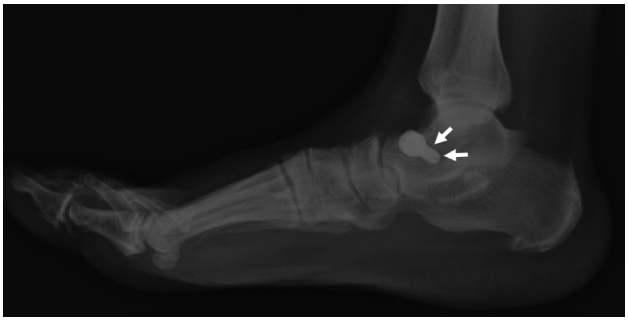

Fig. 2 – Case 2. Lateral radiograph of a 60-year-old girl shows local lucency (arrows) around the arthroereisis screw.

plane gives the best visualization of the arthroereisis implant, which is seen on T1 and T2-weighted sequences as a dark object with associated artifact if composed of metal. Sagittal and coronal imaging planes provide further information on the exact localization of the implant at the sinus tarsi (Fig. 5). Bioabsorbable implants have also been used for arthroereisis. Figure 6 shows an example of an absorbable implant 1 and 4 years after the procedure.

Discussion

A plethora of surgical techniques to treat symptomatic flatfoot deformity have been reported without a clear consensus of proper treatment [7,9,10], which demonstrates the need for a

Fig. 3 – Case 3. Anteroposterior radiograph of the foot of a 12-year-old girl with the arthroereisis implant in place in the sinus tarsi (A). On 2-year follow-up, mild lateral extrusion of the screw (arrow) can be detected (B).

Fig. 4 – Case 4. Axial (A), coronal (B), and sagittal (C) CT images of a 22-year-old man show the arthroereisis implant located in the sinus tarsi between the talus and calcaneus. Minor postoperative changes are observed. The 3-dimensional reconstruction further points out the localization of the implant (arrow; D).

better understanding of subtalar instability and its optimal management [11]. Chambers [12] first introduced the concept of subtalar arthroereisis in 1946, and since then it has evolved to include a wide range of implants. Staples, silicone, thermoplastic, and titanium implants have been studied, but most with short-term follow-up and nonvalidated outcome measurements [11,13,14]. On average, the complication rates range between 4.8% and 18.6% with unplanned removal rates between 7.1% and 19.3% across all device types [7]. However, the reported incidence of implant loosening or breakage has diminished since the introduction of titanium implants [15]. Other complications include overcorrection and undercorrection of the hindfoot valgus, sinus tarsi pain, cortical erosion, inflammatory synovitis, talar avascular necrosis, and calcaneus fractures [11].

Arthroereisis represents a minimally invasive intervention for the treatment of symptomatic flatfoot; while its technical simplicity and rapid recovery may be seen as advantageous, some authors claim this has led to overutilization [16]. Alternative options call for more extensive surgery, increasing operative risk and postoperative recovery [6,7,17]. Furthermore, tarsal joint fusion and osteotomy have potential for nonunion and growth plate disturbances. The most recent literature review by Metcalfe et al. [7] concludes that limited evidence from consecutive case series or case reports exists to suggest that the implant devices may have a more complex mode of action than simple motion blocking or axis altering effects. Ultimately, while a well-established technique, there remains a paucity of information surrounding the safety and effectiveness of arthroereisis [7].

Although radiological measurements have long been applied as markers of success in the management of flatfoot deformity, their relationship to a patient's clinical symptoms and status remains to be proven [7]. However, Needleman [18] and more recent Ozan et al. [19] have reported improvement in the postoperative clinical scores in

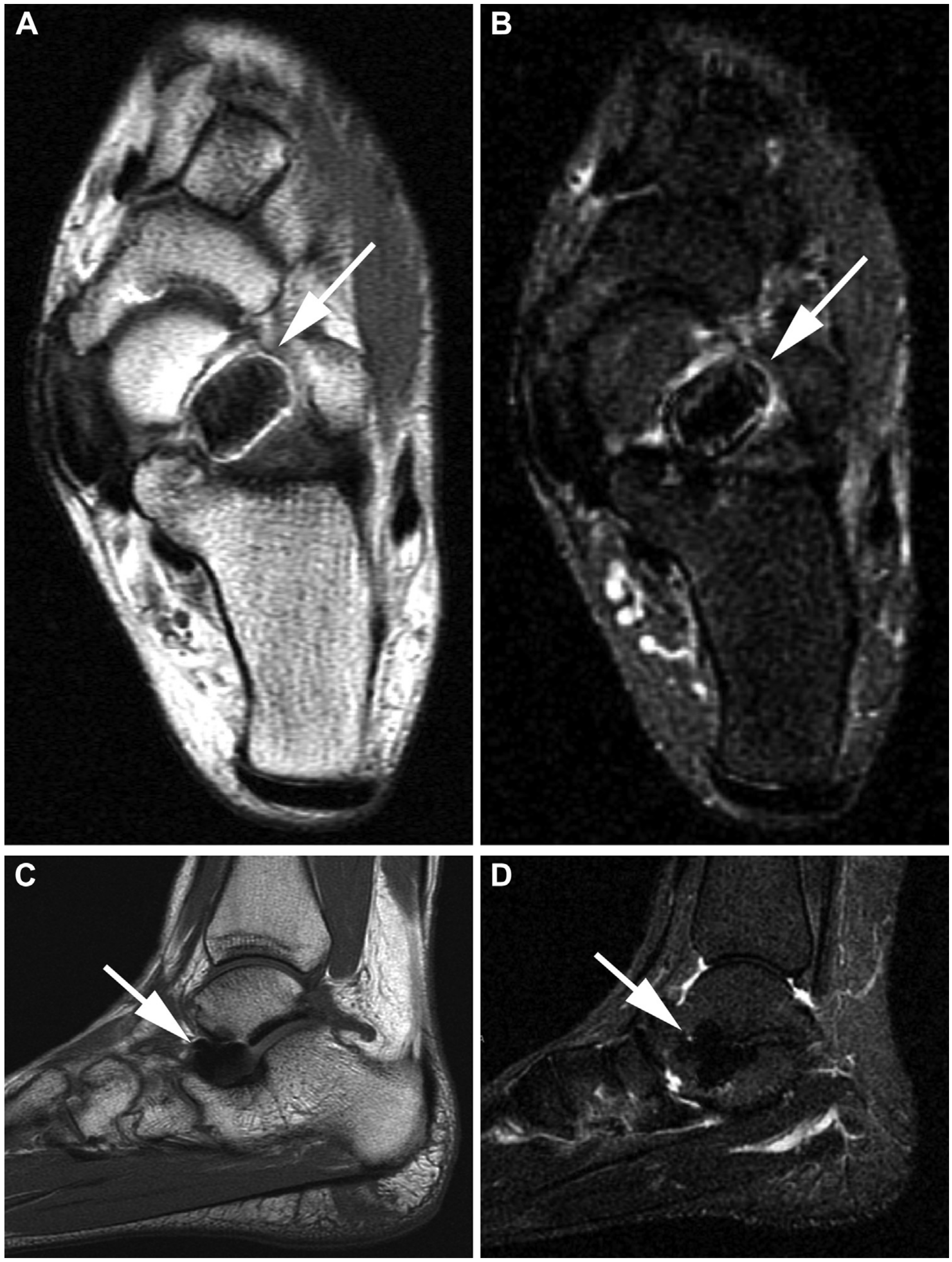

Fig. 5 – Case 5. A 15-year-old girl with post-arthroereisis MRI. On axial proton density (A) and short tau inversion recovery (B) sequences, the implant is seen in sinus tarsi as dark signal focus with a hyperintense rim. Minor bone marrow edema is observed in talus. On sagittal T1-weighted (C) and short tau inversion recovery (D) sequences the standard positioned implant is observed. Arrows point out the implant.

concordance with the improvement of the radiographic variables. Saxena et al. [20] described the MRI findings in 5 patients treated with bioabsorbable arthroereisis screws. They concluded that the size of the sinus tarsi should be carefully evaluated prior the arthroereisis procedure. Furthermore, no cystic or degenerative changes were noted with the bioabsorbable implants [20]. Bali et al. [21] reviewed CT scans of 52 children to assess the anatomy of the sinus tarsi preoperatively highlighting the complex anatomy of the sinus tarsi and emphasizing importance of preoperative imaging for proper fitting of the implant.

Conclusions

In conclusion, arthroereisis is a rare procedure used to treat symptomatic flexible flatfoot. It is essential to have weight-bearing lateral and anteroposterior radiographs to evaluate the medial longitudinal arch of the foot and the subtalar joint space. Radiographs are an excellent screening tool for assessment of implant position. Comparison with prior examinations can document changes in position representing migration, which is the most commonly seen radiologic

Fig. 6 – Case 6. A 49-year-old woman with arthroereisis performed in the year 2009. The first postprocedure MRI after 1 year shows the bioabsorbable arthroereisis implant in the sinus tarsi (arrow in A). Forty-five months later, the follow-up MRI shows the remains of the degraded implant in the sinus tarsi (arrow in B). Axial planes with proton density sequences are shown.

complication. CT and MRI are superior imaging modalities for evaluating preoperative fitting of the implant and post-operative complications.

REFERENCES

[1] 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(2):94.

[2] Sheikh Taha AM, Feldman DS. Painful flexible flatfoot. Foot Ankle Clin 2015;20(4):693–704. Review.

[3] Tareco JM, Miller NH, MacWilliams BA, Michelson JD. Defining flatfoot. Foot Ankle Int 1999;20:456–60.

[4] García-Rodríguez A, Martín-Jiménez F, Carnero-Varo M, Gómez-Gracia E, Gómez-Aracena J, Fernández-Crehuet J. Flexible flat feet in children: a real problem? Pediatrics 1999;103(6):84–6.

[5] Rao UB, Joseph B. The influence of footware on the prevalence of flatfoot. A survey of 2300 children. J Bone Joint Surg Br 1992;74:525–7.

[6] Nelson SC, Haycock DM, Little ER. Flexible flatfoot treatment with arthroereisis: radiographic improvement and child health survey analysis. J Foot Ankle Surg 2004;43(3):144–55.

[7] Metcalfe SA, Bowling FL, Reeves ND. Subtalar joint arthroereisis in the management of pediatric flexible flatfoot: a critical review of the literature. Foot Ankle Int 2011;32(12):1127–39. Review.

[8] Davids JR, Gibson TW, Pugh LI. Quantitative segmental analysis of weight-bearing radiographs of the foot and ankle for children: normal alignment. J Pediatr Orthop 2005;25:769–76.

[9] Kitaoka HB, Patzer GL. Subtalar arthrodesis for posterior tibial tendon dysfunction and pes planus. Clin Orthop Relat Res 1997;345:187–94.

[10] Rathjen KE, Mubarak SJ. Calcaneal-cuboid-cuneiform osteotomy for the correction of valgus foot deformities in children. J Pediatr Orthop 1998;18:775–82.

[11] Chong DY, Macwilliams BA, Hennessey TA, Teske N, Stevens PM. Prospective comparison of subtalar arthroereisis with lateral column lengthening for painful flatfeet. J Pediatr Orthop B 2015;24(4):345–53.

[12] Chambers EF. An operation for the correction of flexible flat feet of adolescents. West J Surg Obstet Gynecol 1946;54:77–86.

[13] LeLièvre J. Current concepts and correction in the valgus foot. Clin Orthop Relat Res 1970;70:43–55.

[14] Crawford AH, Kucharzyk D, Roy DR, Bilbo J. Subtalar stabilization of the planovalgus foot by staple arthroereisis in young children who have neuromuscular problems. J Bone Joint Surg Am 1990;72:840–5.

[15] 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.

[16] Soomekh DJ, Baravarian B. Pediatric and adult flatfoot reconstruction: subtalar arthroereisis versus realignment osteotomy surgical options. Clin Podiatr Med Surg 2006;23:695–708.

[17] Koning PM, Heesterbeek PJ, de Visser E. Subtalar arthroereisis for pediatric flexible pes planovalgus: fifteen

years experience with the cone-shaped implant. J Am Podiatr Med Assoc 2009;99:447–53.
[18] Needleman RL. Current topic review: subtalar arthroereisis for the correction of flexible flatfoot. Foot Ankle Int 2005;26:336–46.
[19] 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;11:1597–602.
[20] Saxena A, Nguyen A. Preliminary radiographic findings and sizing implications on patients undergoing bioabsorbable subtalar arthroereisis. J Foot Ankle Surg 2007;46(3):175–80.
[21] Bali N, Theivendran K, Prem H. Computed tomography review of tarsal canal anatomy with reference to the fitting of sinus tarsi implants in the tarsal canal. J Foot Ankle Surg 2013;52(6):714–6. Erratum in: J Foot Ankle Surg. 2014 May-Jun;53(3):368.