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...
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.

**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
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
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
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.

**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.

**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
complication. CT and MRI are superior imaging modalities for evaluating preoperative fitting of the implant and postoperative complications.

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