

# Use of the arthroereisis screw with tendoscopic delivered platelet-rich plasma for early stage adult acquired flatfoot deformity

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Received: 27 May 2016 / Accepted: 11 November 2016 / Published online: 24 November 2016  
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## Abstract

**Purpose** Early stage adult acquired flatfoot deformity (AAFD) is traditionally treated with osteotomy and tendon transfer. Despite a high success rate, the long recovery time and associated morbidity are not sufficient. This study aims to evaluate the functional and radiological outcomes following the use of the arthroereisis screw with tendoscopic delivered PRP for early stage AAFD.

**Methods** Patients with stage IIa AAFD who underwent the use of the arthroereisis screw with tendoscopic delivered PRP with a minimum follow-up time of 24 months were retrospectively evaluated. Clinical outcomes for pain were evaluated with the Foot and Ankle Outcomes Score (FAOS) and Visual Analog Score (VAS). Radiographic deformity correction was assessed using weight-bearing imaging.

**Results** Thirteen patients (13 feet) with mean follow-up of 29.5 months were included. The mean age was 37.3 years (range, 28–65 years). FAOS-reported symptoms, pain, daily activities, sports activities, and quality of life significantly improved from 52.1, 42.6, 57.6, 35.7, and 15.4 pre-operatively to 78.5, 68.2, 83.3, 65.0, and 49.6 post-operatively, respectively ( $p < 0.05$ ). Statistically significant radiographic improvements (lateral talus first metatarsal angle, calcaneal pitch, and

cuneiform to ground distance) were also observed between the pre- and post-operative images.

**Conclusions** This study elucidates the successful implementation of a less invasive approach to stage IIa AAFD. Through the use of a subtalar arthroereisis screw, PTT tendoscopy, and PRP injection, clinical and radiographic outcomes were improved.

**Keywords** Acquired adult flatfoot deformity · Posterior tibial tendon dysfunction · Arthroereisis screw · Tendoscopy · Platelet rich plasma

## Introduction

The posterior tibial tendon (PTT) is the primary dynamic stabilizer of the medial arch of the foot. In adult acquired flatfoot deformity (AAFD), there is medial longitudinal arch collapse, hindfoot valgus and abduction of the midfoot at the talonavicular joint [1]. This is a temporal sequence progressing from minor degenerative changes in the PTT through four stages with significant malalignment of the architecture of the foot in association with profound degenerative changes in the PTT [2]. The progression of symptoms of AAFD has previously thought to be relentless and progressive, and surgical treatment is typically required to address this progressive deformity.

Traditionally, surgical correction has required hindfoot and forefoot osteotomies, in addition to tendon transfers [3]. While the surgical outcomes of these procedures have been encouraging, the time to recovery can be in excess of 12 months [4] and morbidity associated with extensive surgery is not insignificant [5]. In those patients with early stage AAFD, there is some controversy as to whether early intervention may

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provide early return to function and prevent the progression of the disease process.

The principle of hindfoot stability through an extra articular subtalar arthroereisis has been well documented by Grice and other investigators over time [6]. In recent years, much data has emerged from the paediatric population on the effectiveness of the subtalar arthroereisis screw inserted into the sinus tarsi to address hindfoot valgus [7]. There is a growing body of evidence to support its use in selected cases within the adult population with AAFD [8–14].

Autologous growth factors derived from platelet-rich plasma (PRP) have also been previously shown to help in tendinopathies around the foot and ankle [1]. This biologic adjunct is believed to upregulate a gene within the tendon to produce more tenocytic production [15]. The delivery of PRP to tendons has been a matter of some contention with various methods of intra-tendinous, extra-tendinous and peritendinous injection being advocated either by ultrasound guidance, blinded or by the use of tendoscopic guided injection [16]. Tendoscopic visualization has the advantage over other delivery systems in that minimally invasive debridement of the tendon can also be performed [17].

By addressing mechanical hindfoot malalignment by the use of the arthroereisis screw and improving the biologic milieu of tendon regeneration by tendoscopic debridement supplemented with PRP, it is hypothesized that this combination of therapies will offer patients with early stage AAFD an effective minimally invasive early intervention. This treatment may provide functional recovery and prevent further progression of the disease process. This study aims to evaluate the functional and radiological outcomes following the use of the arthroereisis screw with tendoscopic delivered PRP for early stage (IIa) AAFD.

## Materials and methods

### Subjects

This retrospective study was approved by the institutional review board (protocol #29124). Data was obtained via the Foot and Ankle Data Registry at the authors' institution. Between January 2008 and September 2016 22 consecutive patients underwent subtalar arthroereisis with PRP for AAFD. A single surgeon performed all surgical procedures and provided pre- and post-operative care in all patients. The procedure was indicated for patients with (1) stage IIa AAFD, (2) ability to stand on tip toe on the affected foot, and (3) no obvious tear of the PTT in pre-operative magnetic resonance imaging (MRI) or on sonographer, and (4) failed a minimum of three months conservative treatment, including footwear modification, physiotherapy, and oral medication. Contraindications included patients who had systemic disease,

smokers, patients who suffer from insulin-dependent diabetes mellitus and those who had previous surgery.

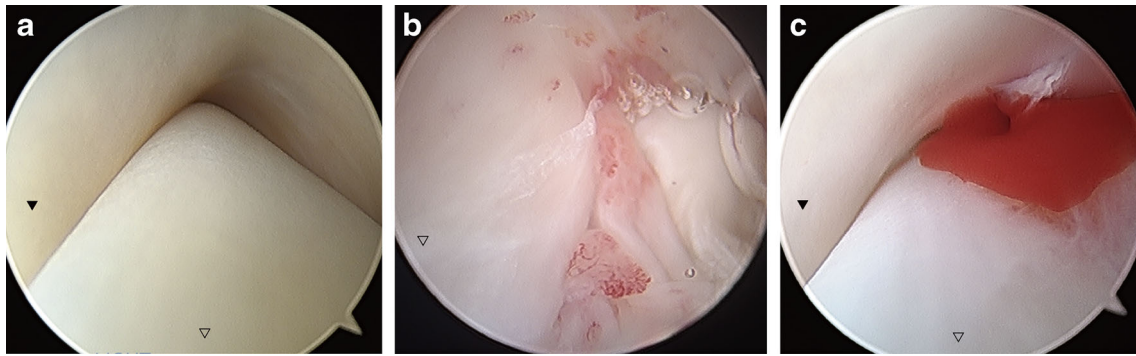
In the present study, patients who had a minimum post-operative follow-up time of 24 months were included. The exclusion criteria were patients who (1) were under 18 years of age and (2) had calcaneal osteotomy surgery for symptomatic flexible flatfoot previously or at the same time, (3) tendon transfer.

### Operative technique

**Blood collection and preparation of PRP** Following induction of anesthesia, 20 mL of whole blood was drawn into a syringe from a vein in the cubital fossa. The whole blood was then centrifuged in a standard fashion with a commercially available system (Arteriocyte, Inc., Hopkinton, MA, USA). The plasma and upper portion of the buffy coat layer were decanted into a separate chamber of the centrifugal bowl. PRP was produced as the platelets were separated from the plasma. Approximately 2–3 mL of PRP was produced from 26 mL of whole blood, with 1.5 mL used for injection into the tendon sheath.

**Posterior tibial tendoscopy** Posterior tibial tendoscopy was performed using the technique previously described [17, 18]. A distal infra-malleolar portal was made over the tendon, approximately 20 mm distal to the posterior edge of the medial malleolus and 30 mm proximal to the navicular tuberosity. At this location, a 22-gauge needle was inserted subcutaneously to identify the tibialis posterior tendon sheath and 5 mL of saline was injected to confirm correct placement. After confirmation of correct portal placement, the portal was incised and a “nick and spread” technique was used to develop the portal and open the sheath of the PTT in order to minimize the risk of the injury to the tendon or neurovascular bundle [19]. A 30° 2.7-mm endoscope was then inserted. The location of the second portal was determined via direct visualization with the endoscope. A 2.7-mm shaver was used to perform tenosynovectomy of the posterior tibial tendon (Fig. 1a, b). A 2.7-mm round burr was used next to deepen the medial retromalleolar groove in which the PTT lies, removing approximately 2–4 mm of underlying cancellous bone. After adequate debridement and decompression, PRP was injected into the PTT under direct visualization with a 22-gauge needle (Fig. 1c). The portals were then irrigated and closed with the figure of eight suture technique using 4–0 nylon.

**Arthroereisis screw placement** An arthroereisis screw alignment rod was placed percutaneously under fluoroscopic



**Fig. 1** Posterior tibial endoscopic views. **(a)** Normal posterior tibial tendon. **(b)** Synovitis of the posterior tibial tendon. **(c)** Platelet rich plasma was injected into the posterior tibial tendon. A *black arrow head* shows the medial malleolus. A *white arrow head* shows the posterior tibial tendon

guidance from lateral to medial through the sinus tarsi (Fig. 2a). A 15-mm incision was then made adjacent to this. The tarsal canal was then dilated and trial sizers were sequentially placed. The optimal sizer limited subtalar joint motion to approximately 2–4 degrees of passive eversion from a neutral calcaneal position. Once the appropriate sizer was determined, intra-operative antero-posterior and lateral radiographs were taken to evaluate sizer placement. The subtalar arthroereisis screw was then placed over the alignment rod, with imaging utilized to confirm appropriate placement, defined by the lateral border of the implant being inline with the lateral border of the talus (Fig. 2b). The wound was then irrigated and closed.

### Post-operative treatment

Patients were transitioned from well-padded splints to controlled ankle motion boots at approximately 14 days following surgery. Sutures were also removed at this time. A weight bearing protocol was commenced at two weeks post-surgery, in which patients were advanced at increments of 10% of their bodyweight each day. Physical therapy was initiated after four weeks. This concentrated on PTT strengthening, balance and proportion training. Patients were allowed to return to

sport and more physical activities at approximately eight to ten weeks after surgery, depending on individual progression.

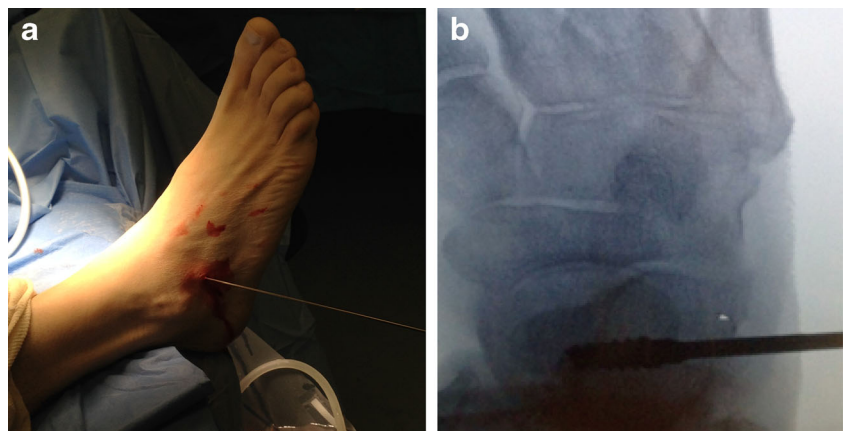
### Clinical evaluation

Patients were assessed pre-operatively and post-operatively using patient reported and general health outcome questionnaires, including the Foot and Ankle Outcome Score (FAOS) [20] and visual analog scale (VAS) score, respectively. Clinical evaluation was carried out at the most recent follow-up.

### Radiographic evaluation

Pre-operative and post-operative radiographs while standing were analyzed to determine radiographic correction of the deformities using lateral talar-first metatarsal angle (LTMA), calcaneal pitch and cuneiform to ground distance. All patients had plain radiographs to monitor two weeks following surgery, and the postoperative weight-bearing radiographs were taken a minimum of three months following surgery. Radiographic measurements were evaluated at the most recent follow-up.

**Fig. 2** Arthroereisis screw placement. **(a)** A guide wire into the sinus tarsi from lateral to medial subcutaneously. **(b)** An implant was placed within the sinus tarsi until the leading edge was one to two threads under the lateral cortex of the talar neck with fluoroscopy



## Statistical analysis

Statistical analysis was performed using SAS 9.3 (SAS Institute, Cary, NC). The Student paired t-test were used to determine significant difference between the pre-operative and post-operative FAOS, VAS scale and radiographic measurements because they followed a normal distribution. A *p*-value of less than 0.05 was considered a statistically significant outcome.

## Results

### Patient demographics

Seventeen patients (18 feet) had subtalar arthroereisis with PRP for stage IIa AAFD, but two patients (3 feet) were excluded, because they were under 18 years of age. Among the remaining 15 patients (15 feet), two patients (2 feet) were excluded because they had combined procedures including medial slide calcaneal osteotomy, tendon transfer, first tarsometatarsal or reverse Cotton osteotomy.

A total of 13 feet in 13 patients who satisfied the inclusion criteria of the study were treated surgically using subtalar arthroereisis screw combined with tendoscopy and PRP augmentation. These patients were a mean age of 37.3 years (range, 28–65 years). Mean follow-up was 29.5 months (range, 24–48 months). Patient demographics and clinical characteristics are shown in Table 1.

### Functional and clinical outcomes

Mean symptoms, pain, daily activities, sports activities and quality of life scores in FAOS significantly improved from 52.1, 42.6, 57.6, 35.7, and 15.4 pre-operatively to 78.5, 68.2, 83.3, 65.0, and 49.6 post-operatively, respectively, at final follow-up (*p* < 0.05) (Table 2). The VAS significantly improved from a pre-operative mean of 7.7 points (range, 6–9) to a postoperative mean of 1.7 points (range, 0–4) at final follow-up (*p* < 0.05).

**Table 1** Patient demographics

Demographic	Value
Total number of patients	13
Number of female patients	9
Number of ankles	13
Number of right ankles	6
Mean age, years (range)	37.3 (28–65)
Clinical follow-up, months (range)	29.5 (24–48)

**Table 2** Results for subscales of the foot and ankle outcome score, and pre- and post-operative radiographic parameters

FAOS subgroups	Pre-operative	Post-operative	<i>P</i> value
Symptoms	52.1 ± 11.3	78.5 ± 7.5	<i>p</i> < 0.05
Pain	42.6 ± 18.8	68.2 ± 9.9	<i>p</i> < 0.05
Daily activities	57.6 ± 9.0	83.3 ± 4.3	<i>p</i> < 0.05
Sports activities	35.7 ± 10.7	65.0 ± 9.2	<i>p</i> < 0.05
Quality of life	15.4 ± 15.1	49.6 ± 6.7	<i>p</i> < 0.05
Radiographic parameters			
Lateral talus-first metatarsal angle (deg)	−6.1 ± 1.7	−1.7 ± 2.2	<i>p</i> < 0.05
Calcaneal pitch (deg)	13.8 ± 0.8	20.2 ± 3.0	<i>p</i> < 0.05
Cuneiform to ground distance (mm)	17.7 ± 2.9	21.3 ± 1.1	<i>p</i> < 0.05

### Radiographic outcome

The results of measurements of all pre-operative and post-operative radiographic parameters are summarized in Table 2. LTMA and calcaneal pitch significantly improved from a pre-operative mean of −6.1° (range, −9 to −2) and 13.8° (range, 9–17) to a post-operative mean of −1.7° (range, −5 to 1) and 20.2° (range, 16 to 24) at final follow-up, respectively (*p* < 0.05). The cuneiform to ground distance significantly improved from a pre-operative mean of 17.7 mm (range, 14–22) to a post-operative mean of 21.3 mm (range, 18–26) at final follow up (*p* < 0.05).

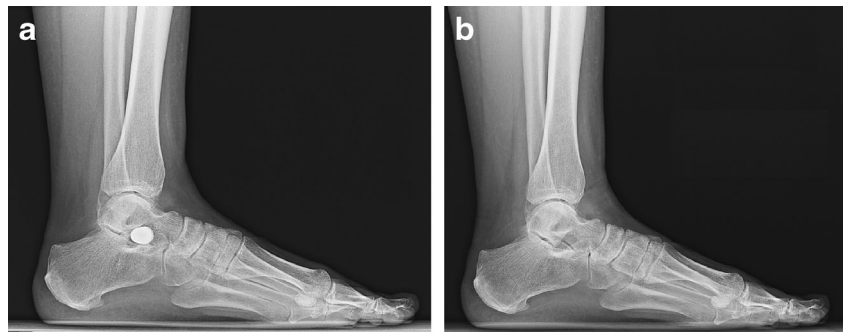
### Complications

Post-operative sinus tarsi pain that was unresolved by the conservative treatments including rest, restriction of activities, and non-steroidal anti-inflammatory drugs was identified in three patients. All three patients who failed local injection treatment underwent removal of arthroereisis screw. The average post-operative time point of removal of screw was 21 months (range, 16–30) after surgery. Their symptoms were completely relieved after removal of screw without recurrence of symptoms, or change in clinical or radiological alignment (Fig. 3).

### Discussion

Stage IIa AAFD is characterized by moderate flexible deformity with minimal abduction through the midfoot [1]. Although conservative interventions are often effective, a significant number of patients with stage IIa disease will ultimately require operative intervention [21]. Traditional surgical management of stage IIa AAFD with correctable hindfoot valgus involves a flexor digitorum longus or hallux tendon transfer to the navicular and a medializing calcaneal

**Fig. 3** **a** Radiograph after insertion of the arthroereisis screw. **b** Radiograph after removal of the arthroereisis screw



osteotomy aiming to normalize the mechanical aspect of this pathology. This may also be augmented with a lateral column lengthening and cotton osteotomy [5, 22]. Previous clinical studies have been associated with excellent outcomes. However, full recovery from these procedures can take up to one year [4]. Additionally, there is the possibility of complications including mal-unions, non-unions, neurovascular lesions, and prolonged immobilization [23]. An alternative surgical option for early AAFD is subtalar arthroereisis, a procedure associated with good functional and radiologic outcomes (Table 3).

The use of a subtalar arthroereisis screw is not without complications, as it relies on restriction of subtalar joint motion to restore mechanical alignment. In 10–33% of patients, this leads to sinus tarsi pain necessitating implant removal (Table 3). Interestingly, this does not necessarily lead to deformity recurrence, as the three patients in this study who underwent implant removal at an average of 21 months after surgery maintained their correction. This maintenance of alignment correction is attributed to restoration of PTT function as a dynamic stabilizer of foot, as it is no longer subjected to great stress as the hindfoot is placed in a more neutral alignment. Additionally, a certain period of time after screw implantation may be necessary to keep foot alignment. To address this, further investigation is necessary.

In the early stages of AAFD, a wide range of PTT pathology can be observed, ranging from mild tendinosis to complete tears. Historically, the FDL transfer to the navicular was indicated in the setting of severe PTT tendinosis, while isolated tenosynovectomy and debridement was used for milder cases. Unfortunately, MRI has been shown to have a low sensitivity for identifying tendon pathology [17]. Gianakos et al. reported a 67% accuracy in the diagnosis of PTT pathology using 3-Tesla MRI imaging. As such, we evaluated the PTT with tendoscopy. This diagnostic approach may benefit the patient via smaller incisions, reduced scar formation and less post-operative pain, particularly when compared to the more invasive

approaches traditionally used to evaluate the PTT intra-operatively.

The efficacy of tendoscopic treatment has been well reported in the clinical literature [18]. The treatment presented in this study included debridement of the pathological lesions with tenosynovectomy of the stenosed, degenerated or frayed tendon. Concomitantly, the medial retro-malleolar groove was also deepened to facilitate this procedure. Additionally, for the lesion resulting from tendinosis, multiple needle insertion was performed to stimulate the cellular response to healing [24]. PRP was also used as a biological adjunct to improve the healing biological environment of PTT. Currently, the efficacy of PRP on tendon pathologies is well supported by in vivo and in vitro systematic reviews [25]. PRP has showed neoangiogenic and tenoproliferative effects for tendon healing in a previous study [14]. However, this study is unfortunately of a small cohort and therefore, it makes it difficult to establish if the primary cause of good outcomes was due to the single factor of PRP with multiple needle insertion and medial retro-malleolar groove deepening.

This study has several limitations, including its retrospective design and small sample size. However, its small sample size is attributed to our strict inclusion criteria. Additionally, we used the FAOS score as our primary outcome measure. This score is increasing in popularity in foot and ankle studies [20], although American Orthopedic Foot and Ankle Society (AOFAS) score is widely used in previous clinical studies (Table 3). But, FAOS may accurately reflect on the patient's clinical outcome more because the FAOS includes more subjective assessments in contrast to AOFAS.

In conclusion, subtalar arthroereisis with tendoscopic delivered PRP is a safe and effective operative technique for treatment of symptomatic stage IIa AAFD. This approach to the flexible flatfoot can address the mechanical and biological sequelae of early stage AAFD.

**Table 3** Clinical studies for subtalar arthroereisis for early stage AAFD

Authors and year	Study design	Feet (n)	Mean age (years)	Mean follow-up (months)	Diagnosis (n)	Combined procedures (%)	Pre. and post. AOFAS	VAS	Implant removal (%)	Significant improvement of radiographic parameters
Viladot et al. 2003 [8]	Case series	19	55	27	AAFD stage II (19)	Tenosynovectomy (42) Tendinous plicature (5) FDL transfer (21) FHL transfer (31) Achilles tendon lengthening or gastrocnemius recession (NA)	47, 82	N/A	11	(+)
Zartel et al. 2003 [9]	Case series	12	49	>12	FF (4) FF with PTT rupture (5) Sinus tarsi syndrome (3)		N/A	N/A	17	N/A
Needleman et al. 2006 [10]	Case series	28	51	44	AAFD stage II (13) AN (3) FF (10) NFF (1) RSL (1)	Achilles tendon lengthening or gastrocnemius recession (100) Cotton osteotomy (42) Lapidus arthrodesis (7) Endoscopic gastrocnemius recession (100)	52, 87	N/A	11	NA
Andelman et al. 2008 [11]	Case series	10	56	>3.75	AAFD stage IIb (10)		N/A	7.0, N/A	10	(+)
Cook et al. 2013 [12]	Case-control study	66	30	>12	FF	FDL transfer (100) Bunionectomy and Lapidus arthrodesis (53) Medial column arthrodesis (6) Metatarsal and lesser digital procedures (37) Posterior muscle group lengthening (43) Calcaneal osteotomy (3) Cotton osteotomy (30) Soft-tissue or Kidner procedure (27)	N/A	N/A	33	(+)
Zhu et al. 2015 [13]	Case series	24	48	29	AAFD stage IIb (24)	FDL transfer (45) Medial slide calcaneal osteotomy (33) First TMT fusion (8) Cotton osteotomy (25) Achilles tendon or gastrocnemius release (54) Endoscopic gastrocnemius recession (62) Calcaneal osteotomy and PTT advancement (27)	51, 85	N/A	21	(+)
Saxena et al. 2016 [14]	Case-control study	104	53	78	Possibly AAFD stage II (104)		N/A	N/A	22	N/A

AAFD adult acquired flatfoot deformity, *Pre.* preoperative, *Post.* postoperative, *AOFAS* American Orthopaedic Foot and Ankle Society, *VAS* visual analog scale, *N/A* not available, *FDL* flexor digitorum longus, *FHL* flexor hallucis longus, *FF* flexible flatfoot, *AN* accessory navicular, *NFF* neurologic flatfoot, *RSL* rupture of spring ligament

## Compliance with ethical standards

**Conflict of interest** The corresponding author (J.G. Kennedy ) is a consultant for Arteriocyte, Inc.; J.G. Kennedy has received research support from the Ohnell Family Foundation, Mr. and Mrs. Michael J Levitt, and Arteriocyte Inc.; J.G. Kennedy is a board member for the European Society of Sports Traumatology, Knee Surgery, and Arthroscopy, International Society for Cartilage Repair of the Ankle, American Orthopaedic Foot and Ankle Society Awards and Scholarships Committee, International Cartilage Repair Society finance board.

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