ORIGINAL ARTICLE

Use of HyProCure in Correcting Flatfoot in Adolescent and Adult Asians: A Radiographic Study Using a New Method of Measuring Hindfoot Alignment

Zhi Hao Tang[1], Keen Wai Chong[2]

Abstract

Aim: Extraosseous talotarsal stabilization (EOTTS) is increasingly popular as a surgical treatment for adult symptomatic flexible pes planus. This can be performed alone or combined with medializing calcaneal osteotomies with or without medial column stabilization. The aim of our radiographic study is to evaluate the changes in various radiographic parameters of a pes planus deformity including hindfoot alignment after EOTTS. We hypothesize that EOTTS can demonstrate improvement in radiographic parameters, including hindfoot alignment.

Materials and methods: A total of 12 feet from nine patients who had undergone EOTTS using the HyProCure implant was analyzed. Weight-bearing radiographs were used to measure the pre and postoperative talar-second metatarsal, lateral Meary's, calcaneal inclination, talar declination angles. Hindfoot alignment was measured using fibular axis calcaneal offset (FACO) method.

Results: Our results showed significant improvement in all the radiographic parameters including hindfoot alignment.

Conclusion: There is a radiographic improvement in a flexible pes planus deformity after an EOTTS procedure, including hindfoot alignment.

Clinical significance: Hindfoot alignment can be corrected with EOTTS procedure with or without associated procedures.

Keywords: Arthroereisis, Deformity correction, Flexible flatfoot, Hindfoot, Pes planus.

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Introduction

Flatfoot or pes planus is a common pathology of the weight-bearing foot that occurs from failure of both static and dynamic stabilizers of the medial longitudinal arch. One of the major levels of failure involves the talocalcaneonavicular joint (coxa pedis) where the apex of the medial longitudinal arch lies. The joint is subject to the pressure of the talar head on weight-bearing and is prone to incomplete separation of articular facets, which then leads to excessive hyperpronation and hence the appearance of a "flat foot" with a valgus hindfoot. The progression of pes planus can be associated with conditions such as hallux valgus, metatarsalgia, tarsal tunnel syndrome, posterior tibialis tendon dysfunction, and in longstanding cases, can lead to degenerative changes of the foot and ankle, causing painful arthritis.

Treatment of the symptomatic flatfoot involves both conservative and surgical options. Conservative measures include supportive footwear and ankle orthosis.[1] Surgery is indicated in patients with symptomatic flatfoot, who had failed conservative treatment. Flexible flatfoot should be treated with extra-articular procedures. This includes both bony and soft tissue procedures such as tendon transfers or lengthening, osteotomies and subtalar joint motion blocking procedures. Arthroereisis (Latin: artro = joint; -eresis = support or prop up) is a joint sparing technique that was originally designed for treating pediatric flatfoot deformities, while preserving foot function.[2] It is postulated that putting in a calcaneum motion blocking device into the sinus tarsi or canal restores the physiological relationship between the talus and the calcaneus during bone remodeling and hence correcting the flatfoot deformity. Recently, the indications are expanding to adults. In 1946, Chambers described using an autologous bone block to fill the sinus tarsi space and thereby restricting motion of the subtalar joint. Lelievre coined the term "lateral arthroereisis" by using a temporary staple across the subtalar joint.[3] He had believed that the most crucial aspect was to block the sinus tarsi and restrict subtalar motion without an arthrodesis. In 1952, Grice described an extra-articular subtalar arthrodesis with cortical graft for paralytic flatfoot deformity in children, which had several issues such as adjacent joint arthritis and inability of foot to adapt to uneven surfaces.[4] In 1977, Subotnick first described using a silicone elastomer as a sinus tarsi implant.[5]

One of the most frequent complications of arthroereisis is sinus tarsi pain which may require implant removal. Saxena et al. reported a removal rate of 22.1% in a study of 100 patients with a larger implant size a risk factor for removal.[6] In his study, age was not a factor for removal. The deformity correction was maintained even after implant removal.[7] There are several described classifications for arthroereisis implants. Vogler divided the implants into sinus

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Conflict of interest: None

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tarsi implants, calcaneo-stop, and tarsi canal implants.[8] Sinus tarsi implants specifically are divided into type I and II implants. A type I device is placed within the lateral half of the tarsi sinus canal, blocking the advancement of the lateral process of the talus. This is placed in a lateral to medial direction instead of the anterolateral to posteromedial direction of the sinus tarsi. As a result over time, it may result in loosening of implant and hence cause pain over the sinus tarsi. A type II device however is inserted and anchored deep into the sinus tarsi canalis, with a lateral conical head achieving the correction. In contrast to the type I implant, it is inserted in an anterolateral to posteromedial direction with stabilization at the entrance of the canalis. The HyProCure is an example of a type II sinus tarsi implant that is used as an EOTTS device.

Materials and Methods

Patients who were diagnosed with symptomatic flexible pes planus and had undergone extraosseous tibiotalar stabilization with the HyProCure implant by the senior author prior to December 2020, were recruited to this retrospective study. The symptoms and signs that these patients presented with included pain along medial longitudinal arch, loss of medial longitudinal arch, "too many toes" sign, and excessive valgus hindfoot. We had excluded patients who had degenerative changes of the talotarsal joints and deformities that were not passively correctable. Pre and postoperative standard weight-bearing anteroposterior (AP) and true lateral views of the foot were performed. In addition, pre and postoperative mortise views of the ankle was done in 10° internal rotation. A total of 13 patients (19 feet) were eligible for recruitment. Preoperative radiographs for seven feet were not available and hence were not included in the study. The data for 12 feet in nine patients were analyzed. The standard surgical technique of EOTTS procedure was performed. Under general anesthesia, the patients were prepared in the usual sterile fashion and placed first lateral on the operating table if an endoscopic gastrocnemius recession has been planned. An endoscopic gastrocnemius recession was performed and the patient was then positioned supine for the EOTTS procedure. The fibula, anterior calcaneal tubercle, the anterior and posterior margins of the sinus tarsi were identified and marked out with a sterile marker. The intermediate branch of the superficial peroneal nerve, the sural nerve and their communicating branch were also marked out. A 1.5 cm transverse skin incision was made 1 cm anterior to the fibular tip. A curved Stevens tenotomy scissors was inserted through the skin incision and through the sinus tarsi, aiming at the posterior aspect of the medial malleolus. The talocalcaneal ligaments are divided using the same tenotomy scissors. The scissors is then removed and a guidewire is inserted through the track created by the scissors. The cannulated trial sizers are then placed into the sinus tarsi using the guidewire as a guide. Once the desired correction is made, the HyProCure stent is inserted and the final position checked with image intensifier. The lateral end of the implants should be deep to the lateral aspect of the talar neck. The pre and postoperative X-ray images were assessed. The talar-second metatarsal angle is measured on the AP radiograph of the foot. The lateral Meary's, talar declination, and calcaneal declination angles were measured on the true lateral radiographs. These angles have been described in literature.[9–11] We measured the hindfoot alignment by using the offset between the fibula axis and the lateral calcaneal wall as shown in Figure 1. A standing mortise view of the patient's ankle is taken with the ankle in 10° internal rotation. This is done in 10° instead of the usual 20° because the tibia is more medially rotated in Asians.[12] The calcaneal wall just inferior to the peroneal tubercle is identified as a sclerotic line (Figs 2A and B). The widest horizontal distance between this line and the mid-fibular axis is measured as an objective measure of hindfoot alignment. This reduces rotational differences in measurement as a mortise view of the ankle can be reliably obtained. We term this measurement as FACO. In our study we chose to use this technique as we believe this method of measuring hindfoot alignment would be more precise, reproducible, easy to perform, and helps to guide preoperative planning. The paired Student's *t*-test was performed to compare the means of the pre and postoperative measurements with p-value < 0.05 accepted as statistical significance.

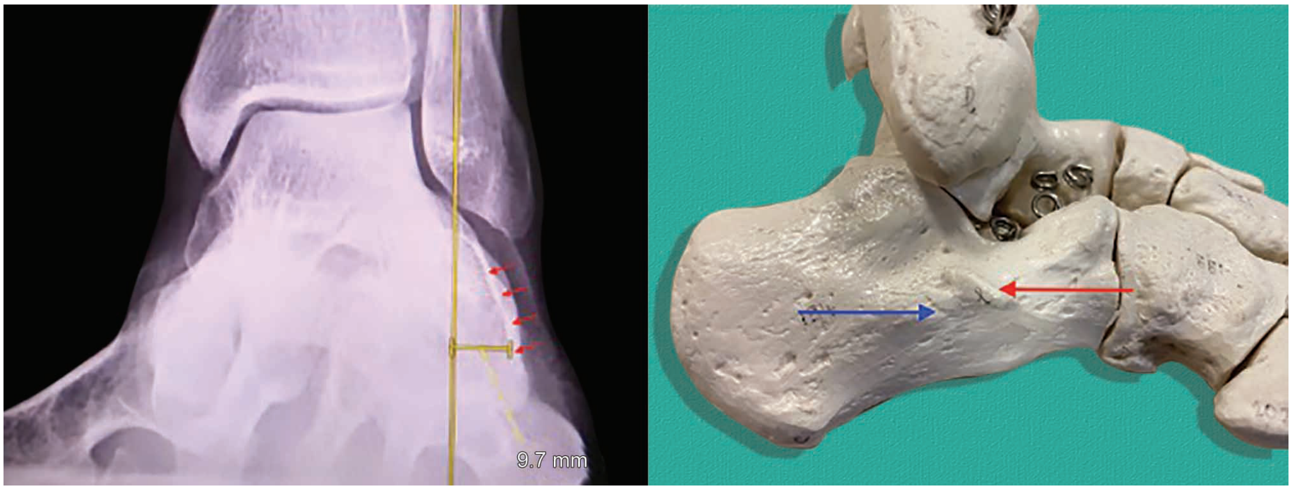
Results

The mean age for the nine patients (five males, four females) was 26.3 years. The age of our patients ranged from 12 to 49 years. Table 1 shows the mean, standard deviation, median, range of the pre and postoperative measurements as well as p values of the paired Student's *t*-tests on the differences in pre and postoperative measurements. Fibular axis calcaneal offset decreased from 7.758 ± 1.67 mm to 3.100 ± 2.683 mm (p-value < 0.001). This represented an improvement of coronal hindfoot alignment. Talar declination decreased from 34.400 ± 3.832° to 25.368 ± 4.003° (p-value < 0.001). Lateral Meary's angle improved from 24.267 ± 5.535° to 9.895 ± 6.557° (p-value < 0.001). However, there was only a slight mean improvement in calcaneal inclination from 12.667 ± 3.244° to 17.105 ± 2.767° (p-value < 0.001). For the talar-second metatarsal angle measurements, an improvement was achieved from 26.533 ± 4.912° to 13.211 ± 5.950° (p-value < 0.001). All parameters had shown statistically significant improvement postoperatively. A three-dimensional improvement of a flexible pes planus deformity was seen with a combination of endoscopic gastrocnemius recession and EOTTS.

Discussion

Subtalar joint arthroereisis is an alternative option to calcaneal osteotomy. The advantages over a calcaneal osteotomy include a quicker and easier procedure to do, no risk of nonunion or malunion, and a potentially earlier weight-bearing and shorter rehabilitation period. Hindfoot malalignment in the coronal plane is a common cause of foot and ankle disability, including progressive dorsolateral

Fig. 1: Measurement of FACO on an ankle radiograph (mortise view)



Figs 2A and B: (A) Sclerotic line (red arrows) representing the lateral calcaneal wall just inferior to the peroneal tubercle; (B) peroneal tubercle on the lateral wall of the calcaneum represented by the red arrow. The lateral calcaneal wall just inferior to the peroneal tubercle is shown by the blue arrow

Table 1: Pre and postoperative measurements

Measurements	*Variables*	*Mean*	*SD*	*Median*	*25th percentile*	*75th percentile*	*Interquartile range (Q3–Q1)*	*Range_ lower*	*Range_upper*	*Paired t-test p-value*
FACO measurements (mm)	FACO preop	7.758	1.670	7.75	6.55	8.6	2.05	5.8	11.8	<0.001
	FACO postop	3.100	2.683	4.1	0	5.2	5.2	0	6.7	
Talar declination angle (degrees)	Talar declination preop	34.400	3.832	35	31.5	36	4.5	28	40	<0.001
	Talar declination postop	25.368	4.003	25	23	27.5	4.5	19	34	
Calcaneal inclination angle (degrees)	Calcaneal inclination preop	12.667	3.244	13	10.5	15	4.5	6	18	<0.001
	Calcaneal inclination postop	17.105	2.767	17	15.5	19	3.5	12	22	
Talar-second metatarsal angle (degrees)	Talar M2 preop	26.533	4.912	27	22.5	29.5	7	18	36	<0.001
	Talar M2 postop	13.211	5.950	14	9	17.5	8.5	1	23	
Lateral Meary's angle (degrees)	Lateral Meary's preop	24.267	5.535	25	21.5	27	5.5	11	33	<0.001
	Lateral Meary's postop	9.895	6.557	8	5	14.5	9.5	0	23	

peri-talar subluxation. Hindfoot alignment correction is vital in correcting a symptomatic pes planus deformity. There are several ways of measuring hindfoot alignment. The more commonly used methods are the hindfoot alignment view (Saltzman), long axial view, and the Meary AP weight-bearing view.[13] The Saltzman view is obtained with patient standing on a platform with medial borders of the both feet parallel to each other and knees in extension. The X-ray cassette is placed 20° from vertical in front of the patient's feet. The X-ray tube is angled 20° from horizontal behind the patient and centered at the level of the ankle, so that the beam is perpendicular to the cassette. The perpendicular distance between the mid-longitudinal tibial axis and the most inferior aspect of the calcaneus is measured.[14] The long axial view is done with the patient standing on the film cassette with medial borders of the feet parallel to each other. The beam is directed from posterior at 45° to the foot at the level of the ankle. The hindfoot alignment is measured by the angle between the anatomical axis of the tibia and axis of the calcaneus. The Meary AP weight-bearing view is performed by passing a flexible malleable wire under the heel and wrapped around the medial and lateral malleoli. The cassette is placed behind the heels of the standing patient. The beam is aimed in a horizontal direction along the axis of the second metatarsal bone perpendicular to the placed cassette. The hindfoot alignment is measured by the angle between the anatomical axis of the tibia and the mid-axis of the outline of the hindfoot as depicted by the malleable wire on the radiograph. Accurate placement of the feet for the above views can be challenging as the foot is often abducted in a pes planus deformity. In addition, placing the medial borders of these feet parallel to each other leads to internal rotation of the lower limbs and hence can affect measurement of the hindfoot alignment. The foot axis is very often abnormally deviated in patients with foot and ankle malalignment and hence is not reliable. As an alternative guide to proper rotational positioning, Haraguchi et al. had suggested using the patella as a guide to control rotation.[15] The FACO method that we use minimizes the rotational error in measuring hindfoot alignment by using the transmalleolar axis as a guide. This method has not been previously described before. Figure 3 shows the varying degrees of hindfoot alignment measured using the FACO technique. This depicts the larger the magnitude of FACO measurement, the larger the hindfoot valgus malalignment. In Figure 4, the left and right radiographs show the FACO measurements before and after an EOTTS procedure. The decrease in FACO measurements represents an improvement in hindfoot alignment (less valgus). Figure 5 shows improvement

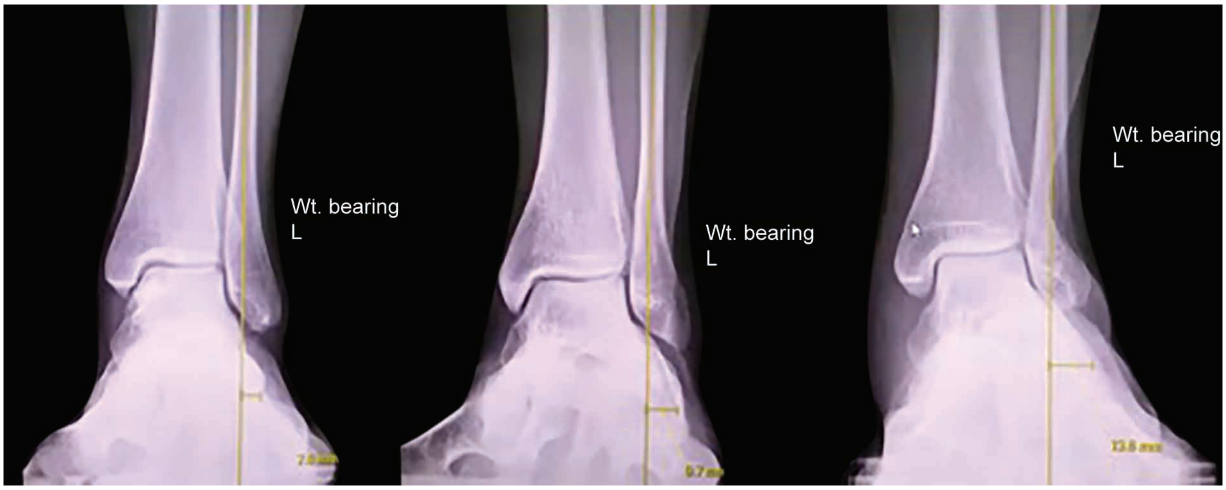


Fig. 3: Measuring varying degrees of hindfoot valgus using the FACO technique

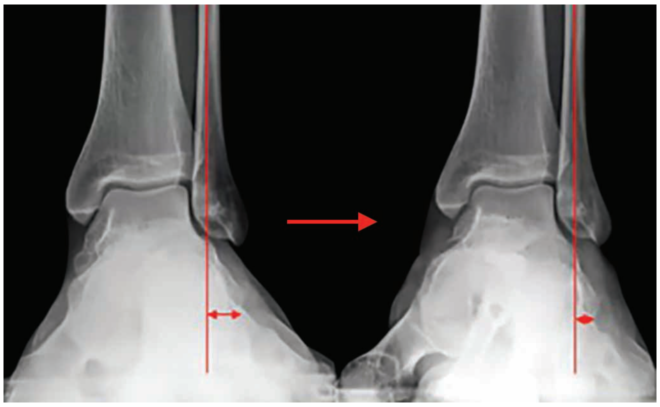


Fig. 4: Improvement in hindfoot alignment after an EOTTS procedure alone

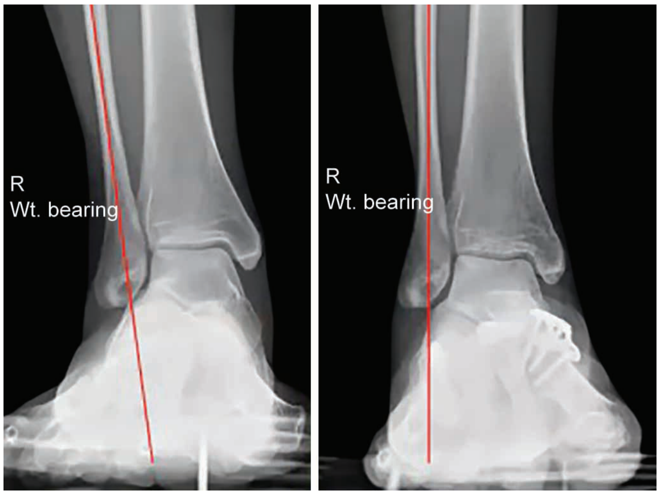


Fig. 5: Improvement in hindfoot alignment after an EOTTS procedure with medializing calcaneal osteotomy and modified Lapidus procedure

in hindfoot alignment in a patient who had undergone EOTTS in addition to a medializing calcaneal osteotomy and a medial column stabilization procedure (modified Lapidus). This patient had a more severe pes planus deformity hence procedures additional to EOTTS were required to achieve correction. This patient had a FACO measurement of more than 12 mm preoperatively. Again, there is a decrease in FACO measurement postoperatively, showing an improvement in hindfoot alignment. Although Graham et al. had showed radiographic improvement in the angular relationships between hindfoot and forefoot in both sagittal and transverse planes,[16] he did not include hindfoot alignment in his study. Our study findings confirm that there is improvement in radiographic parameters in pes planus after EOTTS in Asians. In addition, our study also shows that there is an improvement in hindfoot alignment after EOTTS, which is critical in achieving good outcomes. Extraosseous talotarsal stabilization with endoscopic gastrocnemius recession is able to achieve a three-dimensional correction of a flexible pes planus deformity. However, a more severe deformity requiring a larger correction may need additional procedures such as a medializing calcaneal osteotomy with or without a medial column stabilization procedure. The limitation of our study includes a relatively small sample size.

Conclusion

Extraosseous talotarsal stabilization is an acceptable surgical option for treating flexible pes planus. There is satisfactory improvement in radiographic outcomes, including hindfoot alignment after such procedures. Additional procedures such as medializing calcaneal osteotomy and medial column stabilization can be considered in more severe deformities for further correction.

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