CLINICAL TECHNIQUE

Extra-osseous Talotarsal Stabilization (EOTTS) utilizing Type II Sinus Tarsi Stent: Indications, Technique, and Tips

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Abstract

Introduction: One important reason for a flexible flatfoot is the incongruency or partial dislocation of one or more joints within the talotarsal mechanism. This dislocation or subluxation may exist as a recurrent/dynamic/reducible or rigid/static/nonreducible condition. The flexible talotarsal malalignment is termed recurrent talotarsal joint dislocation (RTTJD). Addressing this malalignment to correct the flatfoot using a minimally invasive technique is the call of the present time.

Aim: To elucidate, in the simplest of manner, the surgical technique of extra-osseous talotarsal stabilization (EOTTS) using a type II sinus tarsi device for flatfoot patients.

Technique: With a 1.5–2.0 cm incision over the dorsolateral aspect of the foot, a type II sinus tarsi device (HyProCure) is inserted into the sinus tarsi after appropriate sizing. Instant and on the table correction of the deformity is achieved. Skin closure can be done with an absorbable subcuticular suture. The entire procedure takes 15 minutes to complete.

Discussion: In the past, many orthopedic surgeons have published their work on flatfoot correction using sinus tarsi implants. Appropriate patient selection and sinus tarsi stent design dictate the success of EOTTS. There have been other soft tissue and bony procedures that have their place when appropriately indicated. However, they result in extensive surgical dissection, big and cosmetically challenging scars, long recovery periods with plasters, and nonweight-bearing instruction. The list of possible and known complications of these more aggressive surgical procedures to correct flatfoot is what led to the development of a more conservative option when indicated. Compliance with custom-made orthotic supports, braces, and shoe inserts is relatively poor. Also, there is no proven clinical evidence that externally applied foot orthotics realigns the osseous structure and restores the normal biomechanics of the foot. With EOTTS, all the above problems are bypassed and the most important advantage is its reversibility.

Conclusion: Extra-osseous talotarsal stabilization (EOTTS) has resulted in excellent improvement in foot biomechanics, alleviation of symptoms like pain and obvious cosmetic deformity, and restoration of normal foot radiological angles. The procedure is a boon for both surgeon and the patient. It allows the patient for a minimal hospital stay and expense, minimal cosmetic scar, immediate correction of deformity, and a very short rehabilitation period.

Keywords: Arthroereisis, Extraosseous talotarsal stabilization, Flatfoot, Recurrent talotarsal joint dislocation, Subtalar implants.

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Background

One of the most common foot conditions found in any age-group across the world is "flat" foot. The primary etiology for the flexible flatfoot is the dynamic incongruency or partial dislocation of the talus on the tarsal mechanism.[1] This partial dislocation or subluxation may exist as a recurrent/dynamic/reducible or rigid/static/nonreducible construct. Flexible talotarsal malalignment is best termed RTTJD. When the foot is nonweight-bearing, during the swing phase portion of the gait cycle, the articular facets of the transverse tarsal joint (TTJ) are aligned. However, upon full weight-bearing, the articular facets become partially dislocated.

A hypermobile, partially dislocating talus is the primary culprit for foot and ankle misalignment. Typical observations may be expressed as a fallen arch (navicular drop), calcaneal valgus, or "too many toes" sign (forefoot abduction). Of greater importance to the physical signs of a partially dislocated talus are the secondary disease processes linked to this internal, weight-bearing disease entity.[2]

The treatment goals of RTTJD are to restore TTJ alignment while allowing a normal triplane range of motion. This will improve biomechanical function in order to reduce tissue strain and provide the individual with a more efficient gait cycle. The least invasive intervention, following orthopedic treatment protocols, should be considered prior to irreversible osseous reconstruction.

Minimally invasive TTJ stabilization has revolutionized the treatment of the primary component of flexible flatfoot. This technique, EOTTS, has been evolving now for more than half a century. EOTTS must be differentiated from a form of arthroereisis referred to as the "calcaneo-stop" procedure. With this procedure, an implant, such as an orthopedic screw, is partially drilled and

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inserted into the talus or calcaneus. This acts as a kickstand to block talar pronatory motion on the calcaneus. The screw is typically removed 18 months after insertion to prevent talar, calcaneal fracture, or deformation. EOTTS implants are intended to remain within the sinus tarsi, unless there is a reason to remove it, such as pain or implant displacement.

There are many subtalar devices in the market. They can be classified into two major types, type I arthroereisis and type II nonarthroereisis.[3]

Type I arthroereisis devices are further subclassified into type IA (cylindrical) and type IB (conical) (Fig. 1).

- Type I device is placed into the lateral portion of the sinus tarsi in a lateral to medial orientation. The instructions for use dictate that the surgeon is to insert this device so that the medial tip does not cross the longitudinal bisection of the talus, thus, not entering into the canalis portion of the sinus tarsi. These devices functions by impingement of the lateral process of the talus to block the talar motion (talar doorstop).[4,5] Type I arthroereisis devices have a reported removal rate as high as 40% or greater (Figs 1A and B).
- Type II (Fig. 1C) nonarthroereisis device, HyProCure (GraMedica, Macomb, Michigan, United States), composed of medical grade titanium, has a lateral conical and medial cylindrical geometry. This implant is inserted parallel to the natural oblique orientation of the sinus tarsi. Its final position should be deep into the tarsal sinus beyond the bisection of the talus in a posterior medial superior direction. HyProCure is held *in situ via* the osseous chamber forming the sinus tarsi, and is anchored medially by the adherence of the transected tissue fibers within the canalis portion of the tarsal sinus and laterally by the lateral grove on the head of the stent. Because of the deeper placement of HyProCure within the natural orientation of the sinus tarsi and the fact that it does not limit or block motion has led to a greater retention rate over type I designs.[6–9]

Indication of EOTTS

Orthopedic surgical intervention is based on the concern(s) of the presenting individual, followed by a clinical and radiologic examination. The entire foot structure must be evaluated, in addition to the overall lower extremity. The primary indication is a diagnosis of RTTJD. It can present as a single disease entity, more commonly associated with coexisting pathologies. The older the individual, the more likely coexisting pathologies will be present.

The presenting concern or complaint for patient ultimately diagnosed with RTTJD, range from asymptomatic to symptomatic pediatric flatfoot or a broad range of secondary pathologies directly linked to TTJ instability, so-called overpronation syndromes including plantar fasciitis, adult acquired flatfoot, posterior tibial tendinopathy, plantar neuropathy/tarsal tunnel syndrome, progress of metatarsus primus varus with hallux valgus, hallux limitus/rigidus, intermetatarsal neuropathy/neuroma, and flexor stabilization hammertoes. The inefficient gait cycle places tremendous mechanical disadvantages to walking and running, ultimately leading to growing pain or so-called shin splints.

The use of an EOTTS stent is not an option until the individual has celebrated their third birthday. The reason is that the chamber forming the sinus tarsi does not become ossified until 3 years of age. The age when a child should undergo corrective surgery is debatable and not the topic of this manuscript. The authors are simply making the point that EOTTS is not an option prior to 3 years of age.

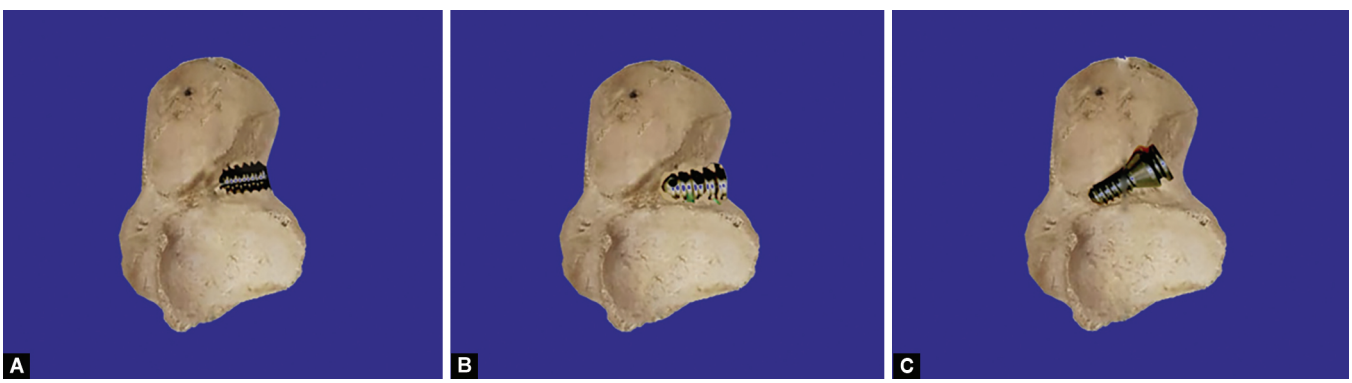
Pediatric symptoms of RTTJD may not always involve a clear indication of pain. Sometimes, children just show a lack of interest or ability in long-standing, walking, running, or for that matter, any sports activity. This has a psychological bearing on their self-confidence. The patient might present with only knee pain or a low backache. A painful, flexible flatfoot is an obvious complaint.

Technique of EOTTS

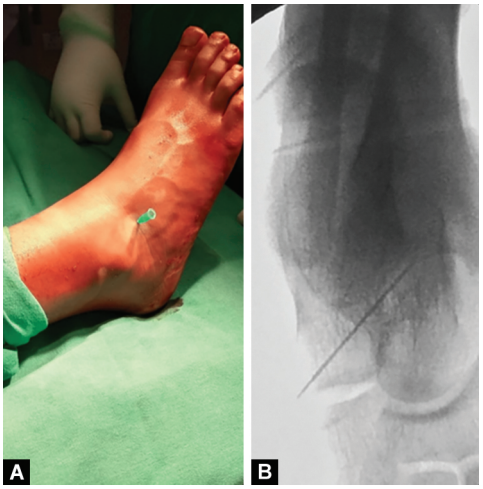
The patient is placed supine on the operating table. The surgeon may choose to add a sandbag on the ipsilateral hip. A tourniquet is not required. Preoperative antibiotics are given within 30 minutes of the incision.

The EOTTS procedure generally takes <20 minutes to perform. Pediatric patients are given general anesthesia. A "twilight" sedation could be offered for older pediatric patients and adults. It is not necessary to perform spinal anesthesia. Regardless of the general anesthesia, it is highly recommended to perform a sinus tarsi injection with a long-lasting anesthetic. While there may be some debate on adding a short-term steroid to the local anesthesia, it is highly recommended to significantly decrease the postsurgical inflammatory response.

The foot, ankle, and lower leg are prepped and draped in the usual sterile fashion. Incision planning is important to ensure direct access to the sinus tarsi. A skin marking should be made for the lateral malleolus and the anterior calcaneal prominence. These landmarks are the proximal and distal boundaries of the sinus tarsi. A soft spot of sinus tarsi is palpated just distal to the tip of the lateral malleolus. Once identified, the surgeon can insert a 21 gauge hypodermic needle obliquely, anterolateral distal to posteromedial proximal (Fig. 2) into the sinus tarsi. If the needle passes without any resistance, then it is definitely inside the sinus tarsi.



Figs 1A to C: (A) Type IA device; (B) Type IB device; (C) Type II device



Figs 2A and B: (A) Hypodermic needle inserted into sinus tarsi in the direction of canalis; (B) Image intensifier image confirming the correct position of the needle

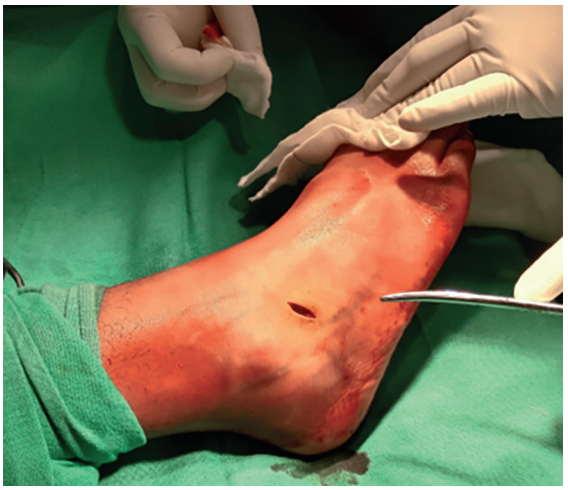
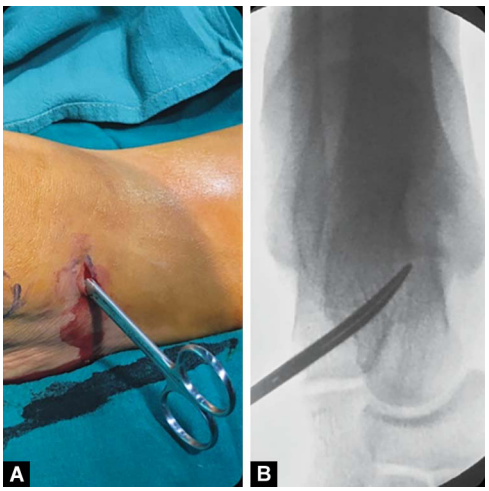
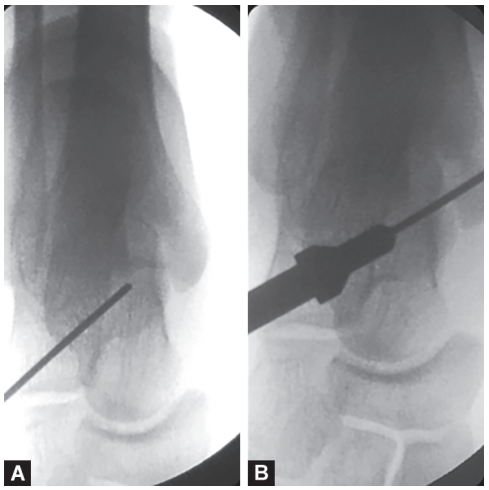


Fig. 3: Incision over sinus tarsi



Figs 4A and B: (A) Scissor placed inside sinus tarsi to cut TCIL; (B) Image intensifier image confirming the correct position of scissor

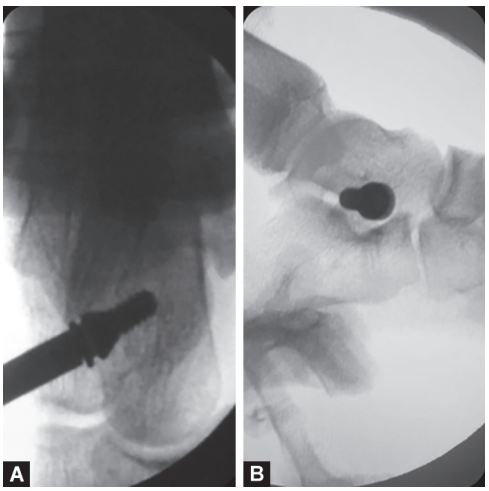


Figs 5A and B: (A) Correct placement of guidewire; (B) Trial sizing being done over the guidewire

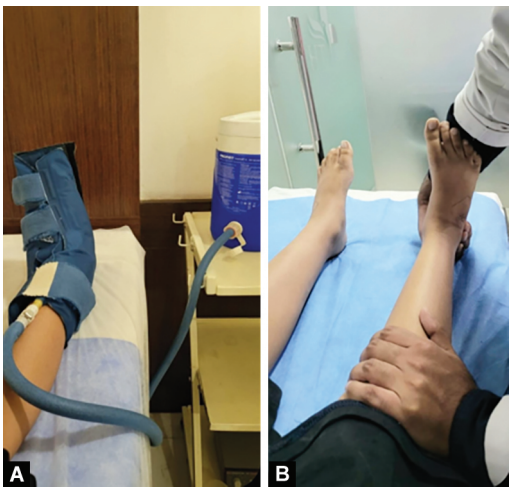
A 1.5–2.0 cm of linear skin incision is made within the natural skin tension lines centered over the sinus tarsi using the number 15 blade (Fig. 3). Once the skin incision is created, the blade is no longer required. The closed tips of a curved tenotomy scissor are then introduced through the dermis. The tips are then expanded to bluntly dissect the superficial entrance to the sinus tarsi. The scissors are then advanced posteriorly toward the posterior aspect of the medial malleolus. The curve of the scissor must be directed posterior rather than anterior. Anteriorly aimed scissors will not decompress the tissues within the canalis portion of the sinus tarsi, talocalcaneal interosseous ligament (TCIL). This will prevent the deep placement of the trail sizer and could lead to improper sizing, placement, and failure of the tissues to adhere to the medial portion of the stent. This step is done to create a pathway for guide wire and trial sizers insertion. It is very important to completely transect the TCIL for proper placement of the sinus tarsi implant. The cut ends of the fibers will auto heal, encircling the threaded portion of the HyProCure stent. This serves as an anchoring mechanism and resists backtracking or displacement of the implant. The position of the scissors can be verified with intraoperative imaging (Fig. 4).

A guide wire should be inserted centrally within the sinus tarsi in an orientation, which should be anterolateral distal to posteromedial proximal (toward posterior medial malleolus). It is important to note that there should be virtually no resistance when introducing and placing the guide wire within the sinus tarsi. If resistance is found, this could be from uncut fibers of the TCIL or the presence of a coalition. The guide wire should be removed, the tenotomy scissors should be reintroduced into the sinus tarsi, and any remaining fibers should be transected. Make sure that the guide wire is not placed lateral to medial and that it is passing entirely within the sinus tarsi and not between the middle and anterior talocalcaneal facets.

After proper placement of the guide wire (as verified by intraoperative imaging) (Fig. 5A), trial sizing is performed (Fig. 5B). The goal is to determine the appropriate stent (implant for EOTTS) size to achieve the desired TTJ pronation and ensure that the stent will be placed deep within the sinus tarsi (Fig. 6). The distal end of the sizer has the outer diameter of the stent size without any threads or grooves to provide for less tissue trauma. The first trial sizer to be inserted is number five. The cannulated sizer is placed on the guide wire and advanced in the same oblique orientation of the sinus tarsi. The tapered portion of the sizer will contact the lateral canalis preventing "too" deep placement. The sizer is advanced deep within the sinus tarsi and verified with intraoperative imaging. Many times, the surgeon will experience a sudden feeling that the sizer has sunk



Figs 6A and B: (A) Correct placement of the HyProCure stent as seen on AP view (the device is entirely medial to the lateral wall of the talus); (B) Correct direction of the stent on a lateral view



Figs 7A and B: Postoperative physiotherapy: (A) Cryotherapy; (B) Passive calf stretch

into the proper position. There could be a palpable click. A correctly placed sizer should be firmly held within the sinus tarsi.

Once the sizer is in place, the TTJ is maximally pronated by applying a dorsolateral force to the fourth and fifth metatarsal necks. The goal is to achieve approximately 5° of TTJ pronation. The surgeon will compare the bisection of the lower leg to the forefoot. If there is >5° of TTJ pronation, the number five sizer is removed, the size six sizer is inserted, and TTJ pronation is again evaluated.

The most common sizes of HyProCure are six and seven, regardless of age. Inexperienced surgeons tend to oversize, thinking once the patient stands, there will be a greater pronatory force on the TTJ. The surgeon should accept the size found intraoperatively. Subsequent sizers will be evaluated until the desired 5° of TTJ pronation is discovered. If the surgeon has to choose between a size that provides more correction, but the stent would sit more superficial over slightly less correction, but the stent would sit much deeper, it is advisable for the surgeon to have the slightly smaller stent that can be placed deeper within the sinus tarsi. The more superficial/laterally placed stents could lead to possible lateral displacement postoperatively.

Once the proper size is determined, the corresponding presterilized stent is inserted. The cannulated HyProCure sinus tarsi implant is placed onto the guide wire and advanced into the sinus tarsi. The cannulated driver is then placed on the guide wire, and the distal tip is engaged into the corresponding lateral end of HyProCure. The surgeon will advance HyProCure into the oblique orientation of the sinus tarsi, aiming posteriorly toward the posterior aspect of the medial malleolus. Once the lateral end of HyProCure passes deep into the skin incision, the guide wire is pulled. This is because there is a dorsal angulation to the sinus tarsi and it is possible that after checking TTJ, a medial bend is placed on the wire, and upon removing the wire, the bend could potentially laterally displace the stent.

The driver is advanced as deep as possible into the sinus tarsi. A key advantage with HyProCure is that, if the correct size is determined, it cannot be "over inserted" or placed too deep. The key is to push it as deep as possible into the sinus tarsi. Then with a twisting motion, the fibers of the cut ligament will encircle the implant. This implant is not a screw and will continue to spin without the tightening effect of a screw. Once HyProCure is placed deep into the sinus tarsi, its position should be confirmed on the image intensifier. A successful placement is that the lateral end of HyProCure implant is deep/medial to the lateral wall of the talus (Fig. 6A).

The superficial tissues over the sinus tarsi are thin, and deep tissue closure could result in excessive scar tissue or prolonged tissue reaction. For that reason, only the skin incision is closed with absorbable subcuticular or 3-0 nylon suture. The closure is followed by the application of a sterile and dry compression dressing. The procedure can very well be done under day-care admission.

Postoperative Course

The patient is instructed nonweight-bearing for 2–3 days postsurgery with limb elevation for the first 24–36 hours after the surgery. Cryotherapy (Fig. 7A) is started after the first look at the wound postoperatively and is given three to four times a day till swelling and pain lasts. On the 3rd–4th postoperative day, partial to full weight-bearing is allowed with a walker as per tolerance. By the end of the 1st week, peronei strengthening, range of motion at the ankle and subtalar joint, and calf stretching exercises are started (Fig. 7B). The patients were allowed to gradually increase activity as tolerated after the 1st postoperative week. They are encouraged to use new sports shoes to walk as soon as tolerated, making sure that the outer collar does not rub against the incision site.

Ideally, EOTTS is performed unilaterally, with the contralateral limb being corrected within 2–3 months. Bilateral correction is not a contraindication, but surgeon experience has shown that unilateral correction provides a quicker return to weight-bearing and is less likely for a partial displacement of the stent during the initial recovery period. Bilateral correction at the same surgical setting extends the recovery process as the patient walks over supinated on both feet until the inflammatory healing process occurs within the sinus tarsi.

Conclusion

Extra-osseous talotarsal stabilization (EOTTS) has resulted in excellent improvement in foot biomechanics, alleviation of symptoms like pain and cosmetic deformity, and restoration of

normal foot radiological angles. The type II sinus tarsi device has been used since 2004, and since that time, there have been no published reports of ill effects on the talus or calcaneus. The implant is extra-articular and is not known to cause arthritis in the subtalar joint. So far, the removal of the implant has been only due to persistent pain and superficial infection, and upon removal of the implant, both issues have been resolved without persistent issues.

Clinical Significance

Correction of flexible flatfoot caused by RTTJD through a minimally invasive technique is a boon for both surgeon and the patient. It provides the patient with an internal correction that works regardless of shoe gear. It doesn't put a patient into plasters, and overall hospital stay and expenses are cut. With minimal incision, the scar is hardly noticed. The possibility of such early rehabilitation is an example of an innovative marvel in medical health.

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