SUBTALAR ARTHROEREISIS

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Introduction

Management of pathological pes valgus deformity represents an ongoing challenge to the podiatric practitioner. Since its recognition nearly one hundred years ago as a surgically correctable deformity, numerous procedures have been developed and modified including soft tissue releases, plications and lengthenings, opening and closing wedge osteotomies with or without bone grafts, arthrodesis of single or multiple joints and more recently arthroereisis of the subtalar joint. The plethora of procedures performed today is a clear indication of the diversity of philosophical approaches to a similar problem. Varying results of the procedures have led to abandonment of some procedures and refinement of others. More recent literature emphasizes the importance of identifying the major plane of deformity (i.e., planal dominance). In fact, it is believed by many to be the single most important variable in determining the appropriate surgical procedure(s) for successful correction of pes valgus deformity.

Subtalar joint arthroereisis represents one of the newest philosophical approaches to the management of pes valgus deformity. Over the past 5-10 years, arthroereisis has gained considerable acceptance and popularity within the podiatric profession. In comparison to more traditional procedures such as osteotomies, arthrodeses and tendon transfers, it is still considered new, the final verdict pending. Although the procedure is generally considered quick, safe, simple in technique, usually successful and with short term convalescence, it is not without specific indications, contraindications, and complications. The purpose of this brief paper is to provide a current overview of subtalar joint arthroereisis with emphasis on the more commonly performed technique of the Sta-Peg procedure developed by Smith.

Historical Overview

According to Dorland's *Illustrated Medical Dictionary,* arthroereisis is the operative limiting of the motion in a joint that is abnormally mobile from paralysis. While arthrodesis prevents all motion across the joint, arthroereisis simply limits or restrains excessive motion; in the area of the subtalar joint the varus range of motion is preserved, the excessive valgus motion limited.

The first attempts at arthroereisis in the foot were performed for paralytic dropfoot and paralytic calcaneus deformity. They involved anterior and posterior bone pegs in the talus and/or calcaneus to prevent motion of dorsiflexion or plantarflexion. The concept of arthroereisis of the subtalar joint is credited to Chambers (1946) who inserted a bone graft under the leading edge of the posterior calcaneal facet to elevate the floor and the facet itself. This elevation would limit the forward and downward excursion of the lateral process of the talus during pronation and prevent it from contacting the floor of the sinus tarsi. Chambers' concepts have served as the basis for current arthroereisis techniques of the subtalar joint.

Procedures similar to that of Chambers have been described to limit pronation of the subtalar joint. Selakovich (1973) described a procedure to elevate the sustentaculum tali (middle facet) thereby creating a medial buttress to prevent talar declination and migration in a plantar direction. Baker and Hill (1964) performed an elevation of the posterior facet by insertion of a lateral bone graft beneath it. This resulted in a varus repositioning of the posterior facet and a shift of the remaining portion of the calcaneus beneath the talus. Vogler suggests that both procedures result in subluxation of the remaining facets of the subtalar joint (i.e., middle and anterior). LeLievre (1970) and Heraldsson (1974) employed homologous bone blocks in the sinus tarsi to accomplish the effects of arthroereisis.

A wide variety of prosthetic devices have been recommended in place on bone blocks in the sinus tarsi. They include a variety of Silastic plugs and free flotation devices (Subotnick 1974, Viladot 1976, Lanham 1979, Vogler 1980, Addante 1982), ultra-high molecular weight polyethylene pegs (Smith and Associates 1976, Lundeen 1985) and threaded screw-like devices (Valenti, Laporta 1984) and a screw "crowned" with a silastic cap (Pisani 1984). A two-part system (Samuelson 1980) of 316L stainless steel and polyethylene has been devised which attaches to the calcaneus and talus respectively.

Vogler has recently classified the various arthroereisis devices into the following categories on the basis of their performance. The first category, **stable self-locking wedges,** are inserted into the sinus tarsi and restrict the end range of motion of the subtalar joint to neutral or varus. They prevent contact of the lateral process of the talus with the floor of the sinus tarsi. The success of the implant is dependent on the fit of the prosthesis against the two opposing surfaces. This category of arthroereisis is best suited for the adolescent and adult patients.

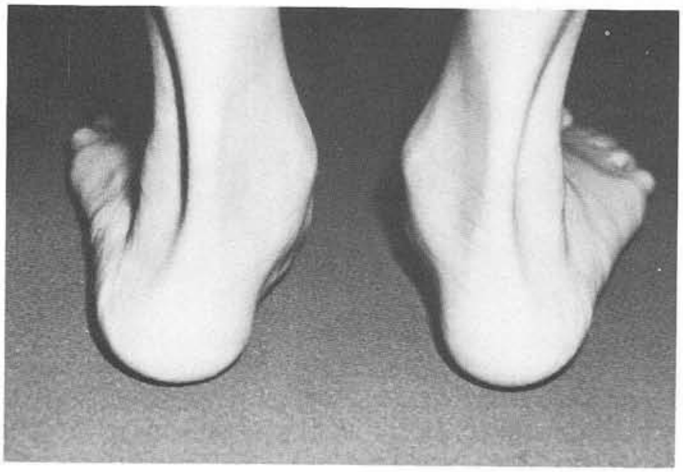


Fig. 1. Severe frontal plane heel valgus in patient with pes valgo planus deformity. Note absence of significant midtarsal abduction.

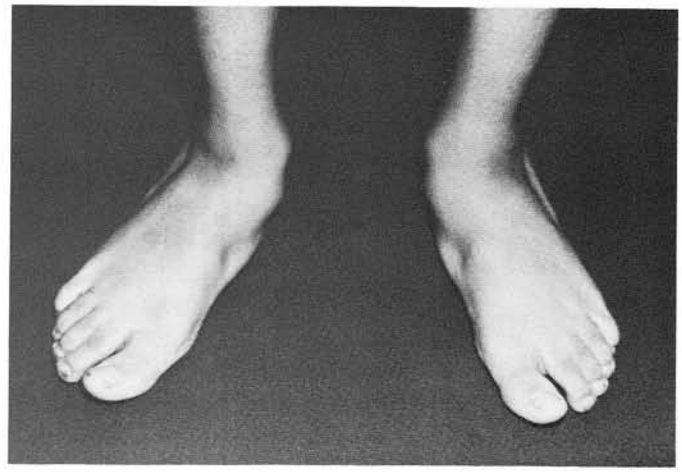


Fig. 2. Clinical presentation of same patient demonstrating talar bulge, total collapse of medial longitudinal arch. Again a distinct midtarsal break is absent.

Fig. 3. Clinical presentation of pronated cavus foot with frontal plane heel valgus.

Fig. 4. Clinical presentation from anterior view.

Fig. 5. Clinical presentation from lateral view demonstrating cavus deformity of same individual as evidenced by failure of the lateral border (arch) to contact the ground supporting surface (pronated cavus foot).

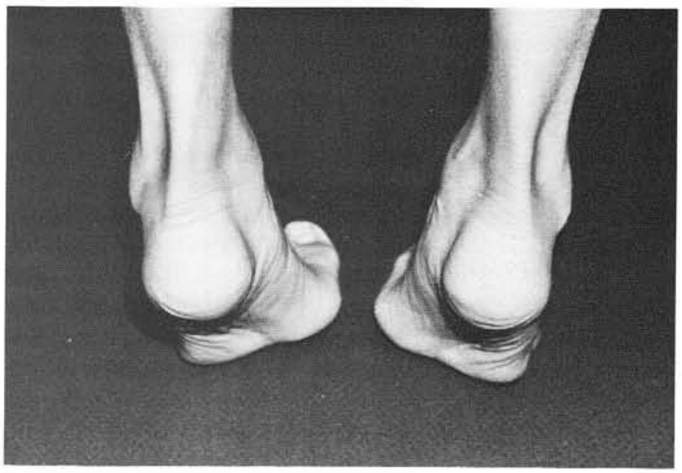


Fig. 6. Heel raise test demonstrating return of heel from valgus to vertical or slight inversion.

The second category, **axis altering** prostheses, which lower the subtalar joint axis, thereby reducing the amount of frontal plane eversion. The STA-Peg is characteristic of this category. Such procedures are generally reserved for the pediatric patient who is able to adapt to the corrected position over a period of time.

The third and final category, **impact blocking** devices which function on the basis of the impingement effect. Once the lateral process of the talus makes direct and intimate contact with the prosthetic device during pronation, valgus motion is limited. These devices stop excess motion in all ages without alteration of the subtalar joint axis. This category includes the majority of the free floating devices inserted into the sinus tarsi. Some of these devices are lueted to the floor of the sinus tarsi.

Clinical Evaluation and Considerations

The technique of subtalar joint arthroereisis is indicated when conservative treatment efforts have failed to adequately control pathological subtalar joint pronation in flexible pes valgus deformity. The procedure is generally performed in patients who have not yet reached skeletal maturity. In some limited situations it may be employed in later years. The appropriate use of the arthroereisis procedure is dependent upon an accurate diagnosis based upon the clinical and radiographic assessment of the deformity.

Although some degree of pain is frequently present, its absence does not preclude surgical intervention. Pain as a sole indication for surgical intervention is ill conceived and improper, especially in children and adolescents. The full functional demands the foot is expected to tolerate are frequently absent in the younger patient, especially when children do not participate in athletic activities. Children frequently fail to communicate minor pain and discomfort. Questioning of both the parents will often reveal the subjective complaints of clumsiness, postural fatigue, refusal to walk long distances or participate in activities, aching pains in the leg or foot, excessive medial shoe wear, and/or medial foot cramps or soreness. These subtle alterations in normal behavior provide useful clues to assessing the degree of disability arising from the pathological pes valgus deformity. These should be considered abnormal in a growing child and should not be explained on the basis of "growing pains."

Clinical evaluation should consist of detailed examination of the foot both weightbearing and non-weightbearing in an attempt to identify the dominant plane of deformity. The most consistent and striking clinical findings will be excessive frontal plane eversion (valgus) of the heel with subtalar joint pronation (Figs. 1, 2). The valgus position of the heel in weightbearing often exceeds 10-15 degrees. Severe depression and obliteration of the medial arch are frequently present, although this finding may be absent in the pronated cavus foot (Figs. 3-5). The physician must realize that severe pronation of the subtalar joint may occur without complete obliteration of the medial longitudinal arch.

The rearfoot valgus deformity should be reducible when weightbearing or non-weightbearing. The heel valgus should reduce when the patient is asked to stand on the ball of the foot with the heels elevated from the ground supporting surface by active contracture of the posterior muscle group (Fig. 6). Failure of the heel to return to a vertical or varus position may indicate a non-functioning or ruptured tibialis posterior tendon or tarsal coalition. Severe subtalar joint arthritis may present similarly. Arthroereisis will be insufficient treatment for pathological conditions. When predominant frontal plane deformity is identified it frequently indicates a rearfoot complex with a low subtalar joint axis. This is the foot ideally suited for subtalar joint arthroereisis.

Flexible forefoot varus or supinatus deformity may be present and exceed 10 degrees. This component must be readily reducible upon manual manipulation. When the subtalar joint is placed in "neutral" position, the forefoot deformity should reduce with manipulation of the medial column (Hubscher maneuver). With the patient standing, external rotation of the leg and thigh with active or passive dorsiflexion of the great toe, should result in a restoration of the medial longitudinal arch and return of the heel to vertical position. If the forefoot varus (supinatus) is due to compensation of an underlying equinus deformity, the equinus must be corrected by appropriate lengthening of the gastrosoleus complex.

Several authors have found less than optimal results when the forefoot varus component is not addressed, especially with patients over the age of 9 to 13 years.

The Young tendosuspension or Kidner procedure alone or combined may be required to reduce the forefoot varus deformity. A tendo Achillis lengthening or gastrocnemius recession is not infrequently required. In younger patients in whom equinus is absent or corrected, the forefoot varus can be expected to reduce spontaneously because of restoration of the tarsal blocking mechanism and resumption of appropriate vector of muscle forces around a stable subtalar joint and rearfoot complex.

A fixed or rigid forefoot varus will not respond to arthroereisis alone. Reduction of the medial column by resectional wedge arthrodesis of the metatarsocuneiform joint, naviculocuneiform joint or both, or opening wedge osteotomy of the cuneiform is usually necessary in such cases. In such patients frontal plane heel valgus represents compensation for the fixed forefoot varus deformity and thus, subtalar joint arthroereisis may not be necessary at all. If accommodated equinus is identified, appropriate lengthening of the gastrocsoleus complex will be required for successful treatment. The precise relationship between forefoot varus (supinatus) and pathological rearfoot pronation and equinus is the subject of ongoing debate. Clearly additional scientific data and detailed studies will be needed to resolve this dilemma.

Clinical assessment must also include an evaluation of the leg and thigh segment to identify any underlying superstructural torsional deformities (internal tibial torsion, femoral neck anteversion) and severe frontal plane abnormalities (genu valgum, genu varum) which may compromise the results of the arthroereisis procedure. These are considered relative contraindications to subtalar joint arthroereisis. The injudicious use in such cases fails to address the underlying etiology of the flatfoot deformity and treats only the manifestations of the abnormality, pathological pronation of the foot. Vogler emphasizes the questionable use of the procedure in as much as normal ontogeny may eliminate the primary contributing etiology of the flatfoot deformity. Arthroereisis procedures should be used selectively in such cases. An increase in adducted gait is likely to occur in cases where internal limb position or torsion is already present. It may or may not be of any consequence.

Arthroereisis is also likely to fail in individuals with a predominant transverse plane deformity of the forefoot and midfoot. Midfoot and forefoot abduction indicate pronation about midtarsal joint and subtalar joint with a high subtalar joint axis. Such transverse plane deformity may be representative of pathological pronation in compensation for metatarsus adductus. This creates the impression of a rectus foot, when in fact the foot is really abducted. Successful use of the arthroereisis will require simultaneous correction of the metatarsus adductus deformity by either soft tissue or osseous procedures.

Failure to identify such deformity preoperatively is likely to result in a clinically apparent metatarsus adductus postoperatively. The fully compensated metatarsus adductus foot appears as a clinical pes valgus deformity and has been referred to as a "skewfoot" or "serpentine" foot.

Other contraindications to arthroereisis include rigid pes valgus deformity, significant arthritis, ankle valgus deformity and prior infection at the surgical site. Children under three years of age, skewfoot deformity, equinus, superstructural torsional abnormalities, severe frontal plane abnormalities and morbid obesity are commonly accepted as relative, or in some cases absolute, contraindications. The treatment of paralytic pes valgus, spastic pes valgus (equinovalgus), tarsal coalition and chronic weakness or loss of tibialis posterior muscle function may involve the use of the arthroereisis procedure. It should be emphasized however, that the arthroereisis procedure is used in combination with other soft tissue and osseous procedures. Used alone, it is likely to result in failure.

Radiographic Evaluation and Considerations

Radiographic evaluation should confirm and correlate with the clinical findings. Dorsoplantar and lateral x-rays should be performed weightbearing in angle and base of gait. Additional x-rays are taken as necessary.

The dorsoplantar x-ray typically demonstrates a talocalcaneal angle greater than 30-35 degrees with 50% or less articulation and congruity of the talonavicular joint. A major anterior break in the cyma line may be seen due to anterior migration of the talus on the calcaneus. The cuboid abduction and metatarsus adductus angle should be minimally increased or normal. Significant increases in either of these angles should alert one to the underlying presence of compensated metatarsus adductus deformity (Fig. 7). It may be helpful to obtain a dorsoplantar x-ray of the foot with the subtalar joint in neutral position (Hubscher maneuver) to better determine the degree of underlying metatarsus adductus. A significantly increased cuboid abductus angle and/or metatarsus adductus angle are radiographic indicators of transverse plane deformity. Widening of the lesser tarsal area on the dorsoplantar x-ray is also considered a manifestation of frontal plane pronation. Clinical correlation is necessary.

The lateral x-ray typically demonstrates pathological pronation of the subtalar joint (Fig. 8). Most frequently, the lateral process of the talus will be seen abutting the floor of the calcaneal sinus and obliterating the sinus tarsi. In some cases a blunting or a hypoplastic appearance of the lateral process of the talus may be evident. Excessive plantarflexion of the talus is commonly present with the talar declination angle may exceed 35 degrees. The bisection of the talus may pass beneath the lower one third of the cuboid. The lateral talocalcaneal angle is usually greater than 40 degrees. An major break of the cyma line is also commonly seen.

The calcaneal inclination angle, although usually low, may be normal or slightly increased especially in the case of the pronated cavus foot. A breach at one or more of the talonavicular, naviculocuneiform and metatarsocuneiform joints is frequently present. Degenerative arthritis of these joints should be carefully assessed for reasons previously discussed. It may also be helpful to obtain a lateral x-ray of the foot with the subtalar joint in a neutral position to determine the ability of such breaches to undergo simultaneous reduction when the pathology in the rearfoot is corrected. If a significant breach of the naviculocuneiform joint is identified, equinus must be carefully assessed. Failure of this particular breach to resolve following subtalar joint arthroereisis has been reported on several occasions.

Other radiographical indications of frontal plane dominance include a decrease in the first metatarsal declination angle, decrease height of the sustentaculum tali, and an increasing superimposition of the lesser metatarsal area of the lateral view.

Other specific x-rays, such as charger views or Harris & Beath view are obtained when additional information is needed. Computerized tomography, tomograms, and nuclear magnetic resonance imaging are reserved for special circumstances such as tarsal coalition.

Fig. 7. Dorsoplantar x-ray showing typical findings of frontal plane pes valgus deformity. Note decreased articulation between navicular and talus, increased talocalcaneal angle, and anterior migration of talus resulting in broken cyma line. Metatarsus adductus and cuboid abduction are within normal limits.

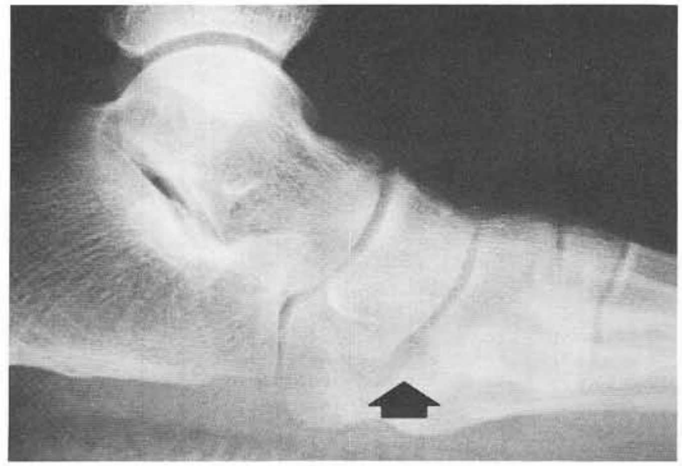


Fig. 8. Lateral x-ray showing increased talar declination, increased talocalcaneal angle, and anterior cyma line break. Also note presence of significant naviculocuneiform fault (arrow) which strongly suggest need for simultaneous medial arch reconstruction in combination with subtalar joint arthroereisis.

Fig. 9. Initial incision for arthroereisis overlying sinus tarsi. Deep fascia is intact.

Technique of the Sta-Peg Procedure

This procedure may be performed under local or general anesthesia with the patient in supine position. It is helpful to place a 10 pound sandbag or similar substitute beneath the hip of the operated extremity to facilitate internal rotation of the leg and foot and thus, facilitate surgical exposure. A pneumatic thigh tourniquet is applied to assist with hemostasis. The foot is prepped and draped in the usual fashion.

A 3-4 cm linear incision is placed over the sinus tarsi. The incision runs obliquely within the skin lines to minimize postsurgical scar formation. The incision runs obliquely from dorsal distal and medial to plantar, proximal and lateral. The incision is deepened through the subcutaneous tissues to the level of the deep fascia overlying the extensor digitorum brevis muscle belly. Particular care is taken to preserve the integrity of the deep fascia overlying the muscle. In addition, care should be taken to avoid damage to the intermediate dorsal cutaneous nerve at the dorsal distal portion of the incision and the sural nerve at the proximal plantar portion of the incision. These nerves are routinely encountered. They may be protected with a penrose drain or other appropriate surgical retractor. Hemostasis is achieved with 4-0 ligatures of absorbable suture or by electrocoagulation (Fig. 9).

The area is carefully palpated and the lateral process of the talus, the sinus tarsi, and the peroneal tendons are clearly identified. The deep fascia is incised in a backward "L" fashion with the vertical portion paralleling the anterior margin of the lateral process of the talus. The horizontal portion runs parallel and superior to the peroneal tendons. The muscle is reflected dorsally and distally exposing the posterior facet of the subtalar joint and the floor of the sinus tarsi (Fig. 10).

The foot is then manipulated and the extent of motion of the subtalar joint observed. With the foot in a supinated position, the anterior edge of the posterior facet of the calcaneus is resected and squared off relative to the floor of the sinus tarsi. Caution is taken to resect only a minimal amount of bone from the facet itself. The sizing template

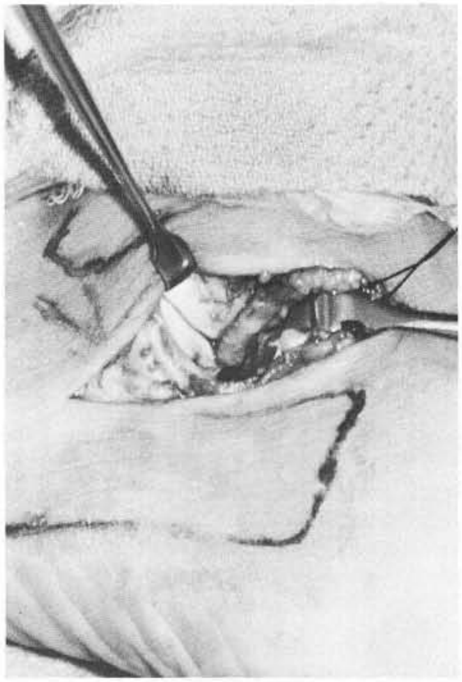
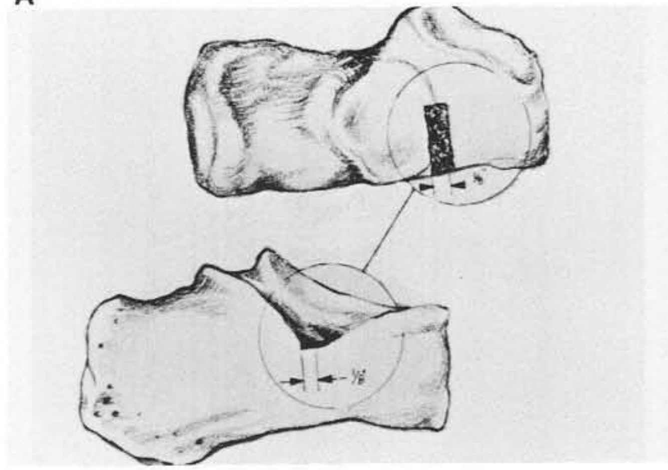


Fig. 10. Deep fascia and capsular tissues incised and reflected dorsally and distally exposing posterior facet and floor of sinus tarsi.

is placed into the proper position and the location of the drill hole determined. A hole is then drilled into the floor of the sinus tarsi, just anterior to the leading edge of the posterior calcaneal facet using the STA-Peg drill guide. It is critical that the hole be drilled perpendicular to the floor of the sinus tarsi and the body of the calcaneus (Figs. 11 A, B). The standard drill hole will necessitate the use of methylmethacrylate to maintain the implant. If methylmethacrylate is not to be used, the hole is drilled with a small round power burr or other appropriate instrument. The STA-Peg sizers are then used to determine the most appropriate sized implant. With a trial sizer implant in place, the subtalar joint is manipulated into the direction of pronation and supination. The appropriate size STA-Peg is then inserted (Fig. 12). The implant is inserted such that the proximal dorsal portion of the implant itself fits flush with the anterior edge of the posterior calcaneal facet (Fig. 13). It is fixated with 0.5 cc of methylmethacrylate if desired.

The wound is irrigated with saline until the cement has hardened. Copious lavage should be performed to assist in cooling the surrounding soft tissue and bone. The tourniquet is released and hemostasis is acquired. The extensor digitorum brevis muscle and deep fascia are then reapproximated with a running stitch of 3-0 absorbable suture. The superficial fascia is repaired with a running stitch of 4-0 absorbable suture and skin via subcuticular closure with suture of choice. The wound is reinforced with steri strips. Short acting steroid and long acting local anesthetic are infiltrated about the surgical site. A dry sterile compression dressing is then applied.

A



B

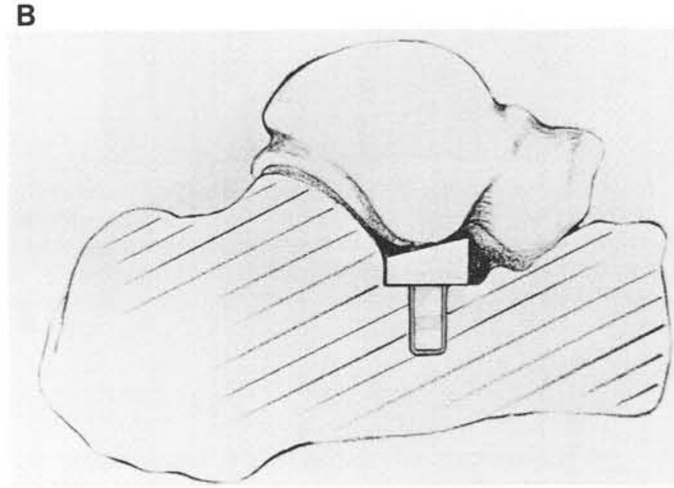


Fig. 11. A. B. Diagram showing desired bone resection and placement of STA-Peg device.

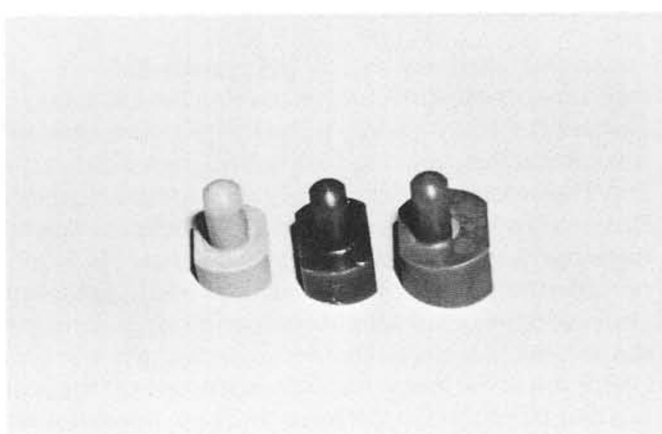


Fig. 12. Three available sizers for angulated STA-Peg device.

Postoperative Management

Although many individuals in the past recommended a short leg cast for varying degrees of time, casting in other forms of immobilization are not usually necessary, unless other major procedures have been performed (i.e., TAL, Young Tendosuspension, medial column arthrodesis).

Early motion and weightbearing in a wooden surgical shoe are highly encouraged. Ambulation is initially limited but generally increases. Full activity is usually achieved in 1-4 months. Other concomitant procedures would dictate the type and length of the immobilization required. After 2-3 weeks of protected weightbearing, patients are permitted to initially return to tennis shoes and gradually permitted to wear any desired shoe. Appropriate orthotic devices are fabricated and dispensed. They are particularly important in those cases where resolution of the residual forefoot varus is likely to require several weeks to months.

Dorsoplantar and lateral x-rays are taken in the initial postoperative period to confirm placement of the device and serve as a baseline for comparison of future x-rays. Serial x-rays should be taken at desired intervals (i.e. 1 month, 3 months, 6 months, and 1 year) to monitor the status of the implant and correction of the foot deformity. Detailed radiographic evaluation should be performed and correlated with the clinical findings.

The decision or necessity to routinely remove the implant devices at some time in the future is controversial. If clinical symptomatology develops that is attributed to the implant device, removal is certainly recommended. CAT scans and NMR may prove helpful in visualization of such pathology. The potential risks versus gain must always be considered.

Implants which function as axis altering prostheses (Vogler's classification) should be considered as temporary implants whose function is outlived once functional adaptation of the talus and calcaneus has occurred. Theoretically, they should be removed. Implants which function as either Stable or Self-Locking wedges or Implant Blocking Devices (Vogler's classification) are considered more permanent, and therefore, over a long period of time may prove more of a problem to remove.

Expected Results

The most dramatic result from subtalar joint arthroereisis is the dramatic reduction of frontal plane heel valgus deformity upon weightbearing (relaxed calcaneal stance position) and during gait. A significant reduction of the forefoot varus can also be expected especially in younger patients with flexible deformity. In other patients (greater than 8-10 years), the forefoot varus component may require concomitant procedures such as the Young tendosuspension or Kidner procedure alone or in combination with a

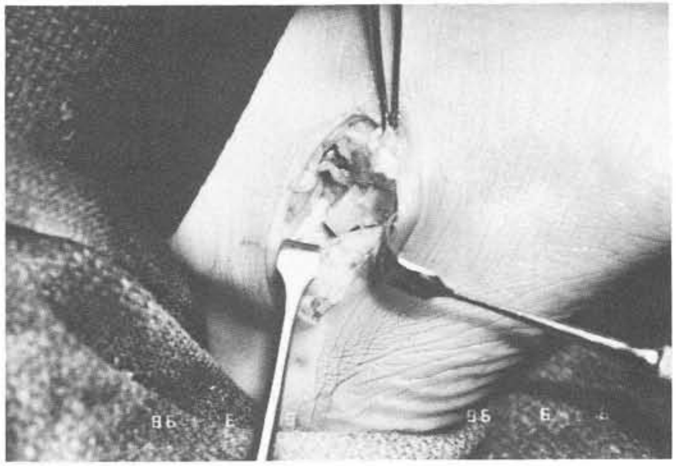


Fig. 13. Intraoperative photo showing STA-Peg device in place at the anterior edge of the posterior facet.

A

B

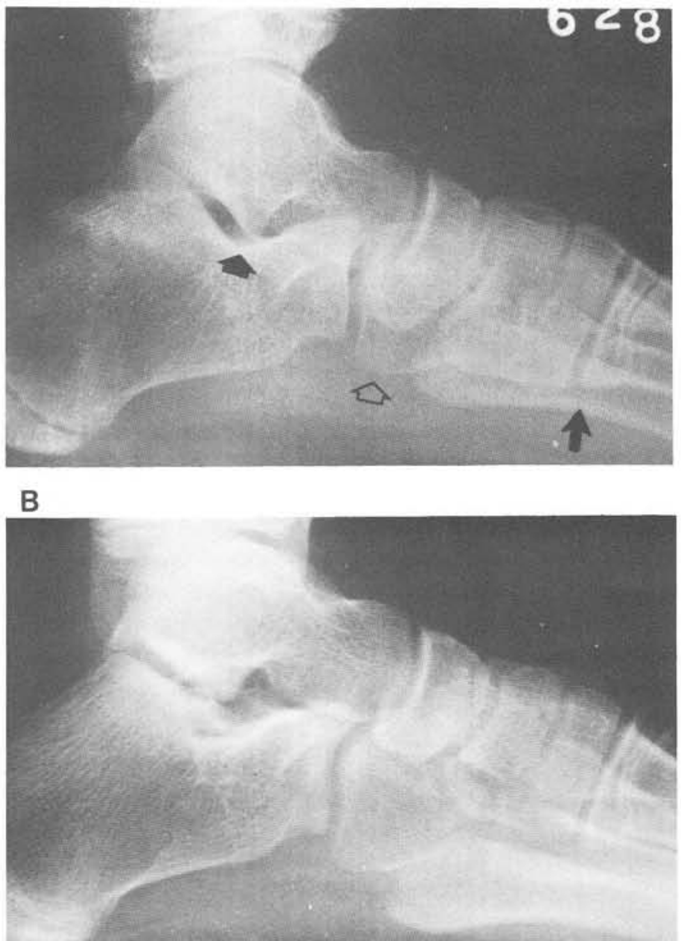


Fig. 14. A. B. Preoperative and 6 months postoperative STA-Peg procedure performed for severely symptomatic pronation with frontal plane dominance.

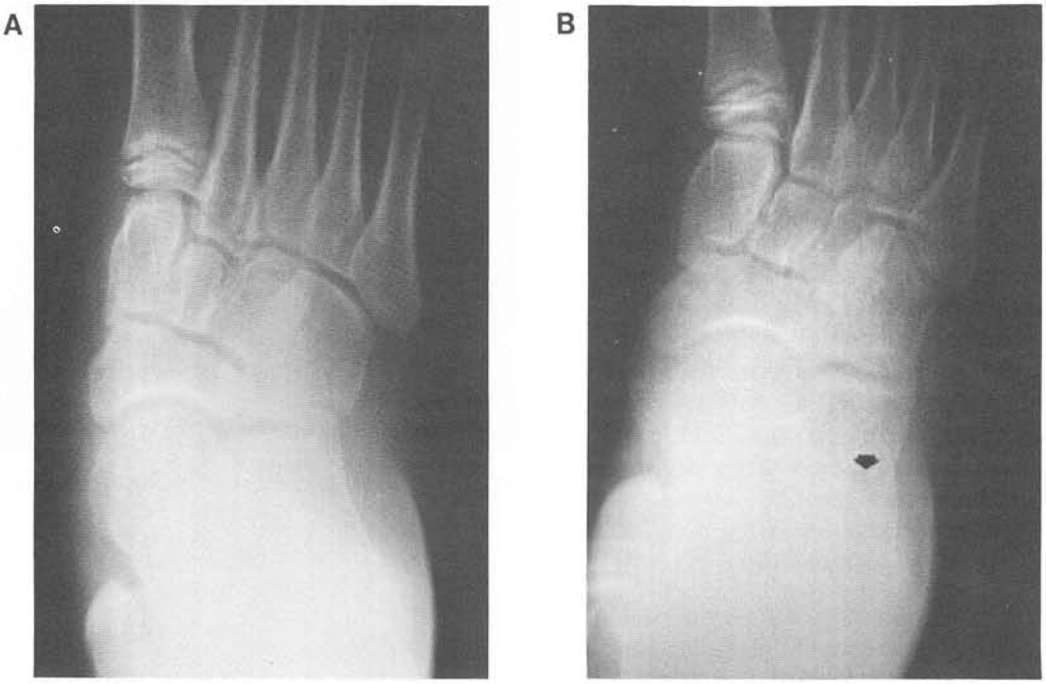


Fig. 15. A. B. Preoperative and 6 months postoperative Sta-Peg.

gastrocsoleus lengthening procedure. Any underlying equinus must be corrected.

Inversion of the subtalar joint after arthroereisis procedure should not be affected significantly although some decrease has been reported. Eversion of the subtalar joint and the total range of subtalar joint motion will be dramatically reduced. Midtarsal joint inversion and eversion are usually unaltered.

A variety of radiographic angles will also demonstrate significant improvement over preoperative values. In two long term followup studies employing the STA-Peg procedure (Smith 1976, Lundeen 1985), a significant decrease in the talar declination and talocalcaneal angles were noted. The calcaneal inclination angle increased an average of 3-4 degrees. Superimposition of the metatarsals was decreased. An improvement or restoration of the cyma line should be evident. Improved congruity of the talonavicular joint is common (Figs. 14 A, B & Figs. 15 A, B).

Fig. 16. Improperly placed STA-Peg device. Implant was not inserted perpendicular to floor of sinus tarsi and thus unable to block anterior migration of talus. Note lateral process is nearly abutting floor of sinus tarsi and is displaced distal to anterior edge of implant itself.

Complications

An extensive review of the literature concerning the arthroereisis procedures reveals a low incidence of complications associated with the arthroereisis device to date. The reader is cautioned, however, to realize that these devices have only been employed for approximately the last 10 years and therefore, cautious optimism is in order. When complications occur they may be attributed to surgeon error in technique, biomaterial failure, or inappropriate application of the procedure itself.

Complications of the various arthroereisis procedures to date include extrusion of the implant, fracture or fragmentation of the implant, fracture of the calcaneus or the lateral process of the talus, and erosion at the bone-implant interface. Improper placement, under correction, over correction and recurrence of deformity have also been reported. Reactive synovitis and infection following the insertion of an arthroereisis device is reportedly low (Fig. 16).

Several potential complications, yet unreported, deserve brief mention. Depression of the implant into the body of the calcaneus secondary to vertical loading might occur particularly in an extremely obese patient. Loosening, deformation or abrasion at the implant bone interface could occur even with the use of methylmethacrylate. Thermal necrosis could result in bone destruction or loosening of the implant due to the large exothermic reaction which occurs with methylmethacrylate. Finally, a non-dose dependent idiosyncratic hepatitis, non-cardiogenic pulmonary edema (hypersensitivity reaction) and bacterial mutagens have all been reported in association with methylmethacrylate use. Meticulous technique is essential to minimize the complications and risks associated with any implant device. Degenerative arthritis of the subtalar joint could also develop as a direct result of excessive or improper arthroplasty technique or the change in position, and therefore function, of one or more of the facets as a result of the procedure. To date, however, this remains an unreported complication.

Poor clinical results (undercorrection, overcorrection, recurrence, substitution of one deformity for another) may be attributed to faulty surgical technique or more commonly inappropriate application of the arthroereisis procedure in the surgical correction of the flexible flatfoot deformity.) Numerous authors have emphasized the importance of identifying and correcting any underlying equinus. The necessity for ancillary procedures to correct naviculocuneiform breach has also been emphasized. Failure to recognize transverse plane deformity as dominant (cuboid abduction, metatarsus adductus) will ensure less than optimal results. In some cases correction of one deformity (subtalar joint pronation) unmasks one or more deformities in the midfoot or forefoot. In such cases, additional surgical procedures will be required to obtain correction (Evans procedure, Berman and Gartland).