STA-PEG ARTHROEREISIS: SURGICAL REPAIR OF THE JUVENILE FLATFOOT

Edward Flake, D.P.M.
Donald R. Green, D.P.M.
Kent Feldman, D.P.M.

There has been a great deal written about the flexible flatfoot deformity and many terms that have been used to describe the entity. "Weak foot, hypermobile foot, flexible flatfoot, compensated talipes equinovalgus, talipes calcaneal valgus, compensated forefoot varus, subtalar or calcaneal valgus, and collapsing pes valgoplanus." Probably the most descriptive label is collapsing pes valgoplanus. Collapsing = flexible; pes = foot; valgo = everted heel; planus = flattened arch. This concisely describes the flexible pronated foot with the flattened arched and everted heel that will be discussed in this paper.

Much has been written about the surgical treatment in the past sixty years.[2,3,4,11,12,21-25,30,32,33,34,36-45,47-51,54-57,59-70,72] This probably stems from the devastating symptoms that can be manifested in the adult who goes untreated.[26,32,36,47] However, symptoms are not limited to the adult foot and may even occur in growing children with the most significant deformities. We must use great caution in dismissing prolonged aches and pains simply as "growing pains".

Arthroereisis is defined in Dorland's Medical Dictionary as "operative limiting of the motion in a joint which is abnormally mobile from paralysis".[7] In the podiatry and general orthopedic literature, subtalar joint arthroereisis has become known as operative limiting of excessive pronatory motion in a flexible flatfoot by blockage in the sinus tarsi area (Fig. 1).

The collapsing pes valgoplanus foot type is one that shows excessive pronation at the level of the subtalar joint resulting in subluxation. The talus rotates medially and adducts with the leg in weight bearing subtalar joint pronation. When this occurs, the talus drops into plantarflexion while simultaneously allowing eversion of the calcaneus.[5,6,33,34,37] Some authors describe the calcaneus and the foot as escaping laterally out from underneath the talus.[4,15] When the foot is planted firmly on the ground the segment that moves in the transverse and sagittal planes is primarily the proximal part (the talus and the leg).[71] However, the end result is the same. The talus carries the weight bearing portion of the ankle, medially displacing it relative to the calcaneal tuber and the remainder of the foot. The arch collapses as the talus

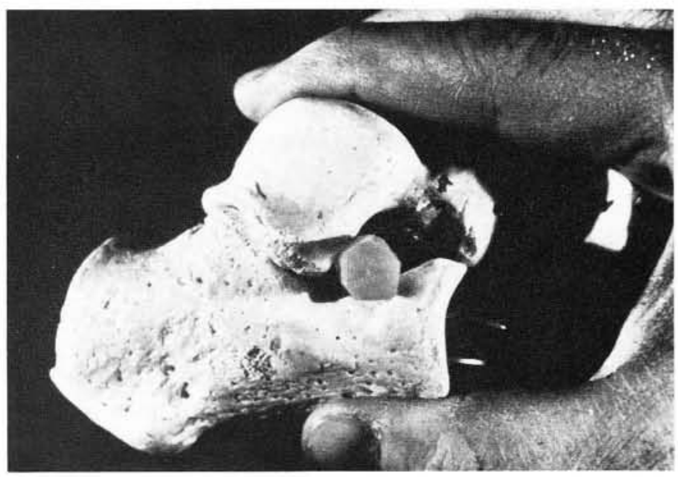

Fig. 1. Silastic plug fills sinus tarsi blocking forward progression of the leading edge of the posterior facet of the talus.

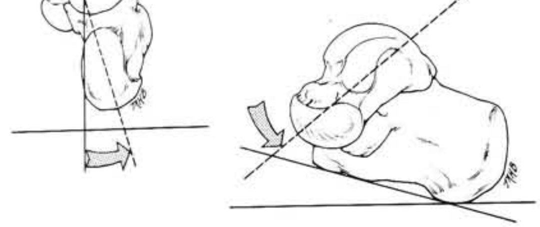

Fig. 2. Pronation of the subtalar joint primarily consists of internal rotation of the talus (and leg), plantar flexion of the talus and eversion of the calcaneus (and foot).

plantarflexes and instability of both the lateral and medial columns of the foot develop (Fig. 2). With this resultant instability, there is hypermobility of all the segments distal to the subtalar joint, and a loss of stability through the lateral column.[53] Over a period of time plantar subluxation of the rear foot (talus and calcaneus) on the forefoot can occur. Once this maximum pronated position has been reached, it is very difficult for the musculature to overcome the reactive force of gravity and supinate at the subtalar joint. Consequently, muscle function becomes ineffective and cramping and fatigue in the leg and/or the arch will generally result. The instability of the joints distal to the subtalar joint can lead to bunion deformity, hallux limitus, grasping of the toes, hammer digit syndrome, plantar fascitis, and metatarsalgia. Postural symptoms such as low back, hip, or knee pain are also likely to develop.[40,53]

The ankle, subtalar, and midtarsal joints make up the rearfoot complex. This rearfoot complex serves as a universal joint that allows transverse plane (medial and lateral rotation) of the leg to be synchronized with the inversion-eversion motion of the foot.[27,28,29,71] When excessive pronation prevents normal resupination of the foot through the subtalar joint, the external rotation of the lower leg is also limited. This can place a transverse plane torque through the knee and lead to the knee pathology such as chondromalacia. Reduced shock absorption capabilities of the foot can develop and lead to jolting through the low back, hip, or knee. Furthermore, additional stress and strain can be placed through the ankle joint and lead to multi-focal symptoms.

Supination is necessary to produce a rigid propulsive foot lever.[5,6] Supination is also required to allow normal external rotation of the leg and to help prevent torquing forces at the knee. Thus, our goal in treating the collapsing pes valgoplanus foot type is to limit the excessive pronatory forces and subluxation while still allowing normal motion through the foot and ankle.[24,25]

There is a great deal of controversy regarding the treatment of the collapsing pes valgoplanus foot deformity in children. Some physicians and pediatricians feel that all kids have flatfoot and that they will "grow out of it". Anyone who has treated the adult symptomatic flatfoot knows that this is a false assumption.[26,32,36,47] However, most kids under the age of 3 $^{1}/_{2}$ to 4 $^{1}/_{2}$ have an under-developed neuromuscular and skeletal system. For these kids normal maturation of the arch structure with growth can be expected. A better means of identifying those kids with severe subluxing pronatory forces from those with the under-developed "normal" foot types must be disseminated. Those physicians without the knowledge of the devastating results of this deformity in adulthood would opt to "do no harm" by not treating these children at all. This ignorance may in fact be doing the most harm by condemning the individuals to pain and suffering at a later time.[25,26,36,64]

The earlier the treatment can be instituted in children (whether it be conservative or surgical) the better the chance of neutralizing and correcting this problem.[13,25,26,45,63] It is obvious that continued abnormal loading of the foot in a growing child will lead to further pathologic displacement and will result in abnormal structural development in the skeleton and soft tissues. In the growing child, this will eventually lead to permanent adaptation to the deformed position and a significant increase in symptoms.[25,26,45,63] Cowell makes the statement that for every day that treatment is delayed in the growing child, a golden opportunity is lost forever.

Probably less than 2% of the collapsing pes valgoplanus foot types require surgical intervention. However, for those requiring surgery the earliest intervention allows the most rewarding results. In general for the younger patient, the more simple, less complicated, and less disabling procedures can be performed.

The surgical procedures for flexible flatfoot fall into four general categories. 1) Ligamentous intervention such as the medial tightening procedure of Milch and Schoolfield.[47,56] 2) Tendon lengthenings, tenoplasties, or transfers such as a medial displacement of the Achilles' tendon by Gotch, shortening of the flexor hallucis longus and attachment of the tibialis posterior by Hubschure, tibialis anterior tendon transfer by Young and Mueller, the anterior advancement of tibialis posterior by Kidner, the medial arch procedure by McGlamry and Smith and Weil, gastrocnemius lengthenings, and tendo-Achilles' lengthenings.[72,33,34,3,30] 3) Bony procedures such as calcaneal osteotomies that relocate the tuber ala Gleich, Dwyer, Silver, Koutsogiannis and Lord, the Evans-calcaneal lengthening osteotomy, the Hoke navicular cuneiform fusion, the Miller first metatarsal cuneiform, cuneiform navicular fusion with anterior advancement of insertional flap of the tibialis posterior, the Loman procedure with talonavicular fusion and relocation of the tibialis anterior, to Leavitt's subtalar joint arthrodesis procedure, the Grice procedure of extra-articular arthrodesis of the talocalcaneal joints and triple arthrodesis procedures of Reyerson, etc.[16,11,60,61,32,43,12,30,48,44,41,21,22,23,54] 4) Arthroereisis procedures - blocking excessive pronation of the subtalar joint while allowing the normal range of motion is the final category.

Green, et. al., demonstrated in their radio-cinemagraphic movie of the foot that in maximum subtalar joint pronation the leading wall of the posterior facet of the talus occludes the sinus tarsi.[20] In supination, the sinus tarsi opens and is almost like a bullet hole in shape. The movie visually demonstrated what many authors had already realized from anatomic dissection and biomechanical studies. If the sinus tarsi can be blocked, the end range of pronation can be significantly reduced.[2,4,24,25,45,55,59,63,39,40,42,65,66,67,68,69] This has lead to the development of a number of arthroereisis procedures. The goal of treatment in the collapsing pes valgoplanus foot type is to limit the excessive pronation of the subtalar joint without limiting normal supination. This will allow a more physiologic function throughout the remaining joints of the foot and the leg.[42]

There are a number of authors that attempted bony procedures to produce blocking of the excessive subtalar joint pronation. Chambers, in 1946, elevated the calcaneal sulcus attempting to block the forward progression of the posterior facet of the talus into the sinus tarsi, thereby eliminating the excessive pronation.[4] Baker and Hill, in 1964, elevated the posterior facet of the calcaneus with a bone graft, attempting to do the same thing.[2] Selakovich in 1973 elevated the sustentaculum tali with a bone graft attempting to prevent the talus from adducting and plantar flexing over this area.[59] LeLievre placed a pyramidal or conical homogenous bone graft into the sinus tarsi with the base laterally to block the pronatory motion.[42] Haraldsson in 1974 placed a bone graft in the sinus tarsi after roughing the calcaneal portion and attempting to preserve the dorsal talar area by covering the graft with soft tissue.[24,25]

There have been a number of subtalar joint arthroereisis procedures using silastic blockade. Subotnick in 1974 and 1977 used a silastic mold with or without the use of a temporary staple to block the excessive pronation.[66,67] Villadot in 1976 used a champagne glass shaped silastic plug in the sinus tarsi. Lanham in 1979 used the stem of a Swanson great toe hemi-implant for blockade.[40] Vogler in 1980 used a Swanson hemi-implant in the sinus tarsi to block the forward thrust of the posterior facet of the talus.[68,69] Addante used silastic spheres in 1982 in the sinus tarsi.[1] Sgarlato in 1983 used mushroom shaped silastic to block the forward progression of the posterior facet of the talus. Shoenhaus in 1987 reported on his modified fashioned silastic plug in the sinus tarsi.[57] Other forms of subtalar joint arthroereisis include Samuelson's stainless steel and polyethylene two-component arthroereisis. This procedure also included talonavicular stainless steel and polyethylene components.[55] Valenti in 1984 described the arthroereisis technique using a threaded polyethylene screw in the sinus tarsi.[39] Pisani in 1984 demonstrated the stainless steel screw blockage using a silastic crown on the head of the screw.

Results of the subtalar joint STA-peg arthroereisis were reported by Smith et. al., in 1983 and also by Lundeen in 1985.[63,45] The STA-peg utilized a disc of high molecular weight polypropylene with a stem that was placed into the floor of the sinus tarsi in such a manner that the leading edge of the posterior facet of the talus would glide up onto the disc to block the forward progression (medial rotation) and depression of the body of the talus. This would thereby prevent excessive pronation (Fig. 3). The STA-peg was later modified to be angulated to help afford further blockage. STA-peg implants are available in 5 sizes at the present time and are F.D.A. approved (Fig. 4). The results of both Smith and Lundeen are very favorable. Our modification that was developed by Edward Flake in conjunction with Dale Austin angulates

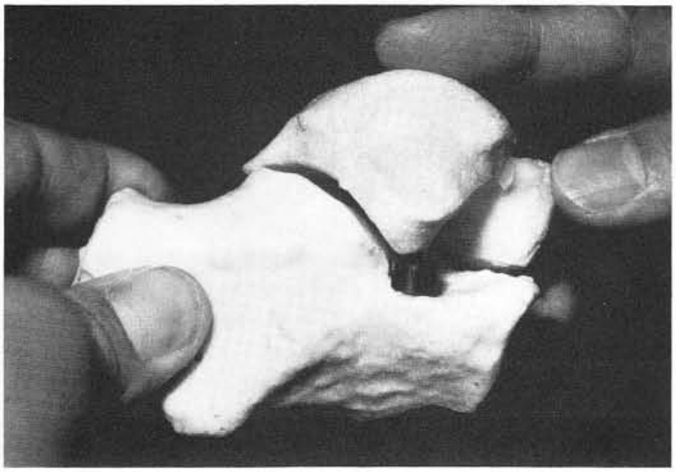

Fig. 3. Smith STA-peg prevents forward progression of the leading edge of the posterior talar facet with the STA-peg positioned vertically in the calcaneus as shown above.

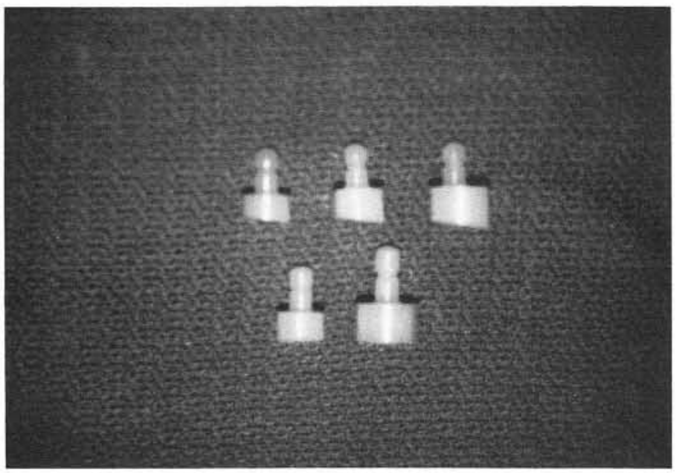

Fig. 4. 5 sizes of the STA-peg are available:

Angled	- small
	- medium
	- large
Straight	- small
	- medium

the STA-peg at approximately a 45 degree angle so that the flat surface of the disc will resist the lateral leading edge of the posterior facet of the talus across its entire surface (Fig. 7B).

The clinical indication for the STA-peg arthroereisis is generally in a growing child with postural symptoms. These can include persistent "growing pains", leg or night cramps, arch pain and fascitis, apophysitis, shin splints, low back and knee pain, or multi-joint involvement symptoms. It is certainly abnormal for a child to have persistent "growing pains". The cause for such symptomatology must be explored. This is especially true since many times kids are having symptoms of pain or fatigue and have experienced such symptoms all their life. They may not realize that these symptoms are abnormal and that everyone doesn't have the same type of fatigue. Therefore, complaints of symptoms may not be registered at all. It is much more important to carefully explore the history of these patients for such things as sedentary preferences and walking temperance.

Sedentary preferences include 1) the young child whose hobbies are primarily those that require no weight bearing such as chess or cards, 2) the child that avoids athletics or even normal playground activities at school, 3) the individuals that are pudgy and will not exercise, 4) those kids that are always sitting on the sidelines rather than participating in games and 5) those kids that would prefer video games to the exclusion of any activity requiring exertion.

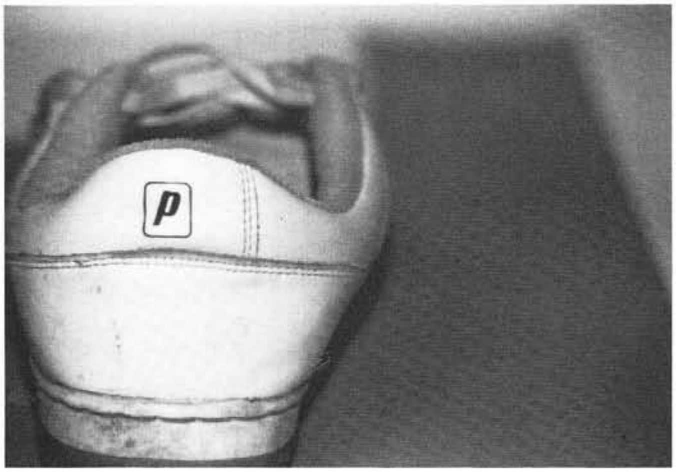

Fig. 5. Abnormal shoe wear and break down may include break down of the heel counter, breakdown and collapse of the medial shank, and rapid medial heel and shoe wear.

Walking temperance can give additional clues to painful collapsing pes valgoplanus foot types. 1) Those kids who may not enjoy amusement parks such as Disneyland because of foot fatigue, 2) those who are constantly complaining about walking in the malls or always want to be carried, 3) the clumsy individual who is falling and tripping frequently, and 4) the individual who has shoe intolerance and is constantly removing his/her shoes. This child may be reacting to the pain and resistance of the shoe gear.

The family history can play a significant part in the early detection of these subluxing foot types. Offspring or siblings of patients who have the painful collapsing foot type should be examined at an early age. Foot type and structure generally tends to be inherited, although the symptoms associated with a specific deformity may not become evident until subluxation occurs or lifestyles change.

However, the most common reason for parents to seek attention for their children is abnormal foot appearance, walking patterns, and shoe wear. Abnormal shoe wear may lead to early break down of the counter or shank requiring frequent replacement. An everted counter, a collapsed medial shank, and/or an abnormal medial heel and sole wear pattern are the usual signs (Fig. 5). Once these patients present to the office, a close examination of the foot will usually reveal a flexible deformity that is readily reducible. In a relaxed stance position the child will have an eversion of the calcaneus that's greater than 5 to 8 degrees, a depressed arch with medial prominence of the head of the talus plantarly, and a lateral subluxed position of the foot and the heel relative to the ankle and talus. In gait the patient will strike with the heel maximally pronated and remain pronated throughout the gait cycle. Many times children with greater physical strength may undergo a late resupination, although this in no way approximates a normal condition.

Radiographic evaluation is often times not even required. However, the lateral talocalcaneal angle and the talar first metatarsal angle are very valuable measurements on the lateral x-rays.[9,50] Specific areas to examine are the position of the anterior edge of the lateral talar process, the degree to which the sinus tarsi is occluded, and the position of the sustentaculum tali.[17,20,14] On the dorsal plantar view the talocalcaneal angle and the talar first metatarsal angle will also provide help in determining the amount of pronation and subluxation that is present (Fig. 6A, 6B). The calcaneal inclination angle is more of a structural angle and does not change very much with supination and pronation. It is better used to determine the overall foot structure (a cavus, normal, or flat foot) as opposed to determining the degree of prona-

Fig. 6A. In the lateral weight bearing radiograph in flexible flatfoot 1) the lateral talocalcaneal angle is generally increased from the normal 45°, 2) the talo-1st metatarsal angle is negative, 3) the leading edge of the talar posterior facet occludes the sinus tarsi.

Fig. 6B. The dorsal plantar weight bearing radiograph in flexible flatfoot is larger than the normal 18°.

tion.[9] The talar declination angle is not quite as helpful as the lateral talocalcaneal angle due to the variability of the structural calcaneal inclination angle. In a high arch pronated foot, the talar declination angle may fall within normal limits as a result of the excessive calcaneal inclination. However, the lateral talocalcaneal angle should be significantly increased. The normal value for the lateral talocalcaneal angle is approximately 45 degrees, for the normal calcaneal inclination angle 19 to 30 degrees, for the normal talar declination angle 21 degrees, and for the normal lateral talar first metatarsal angle 0 degrees. The sinus tarsi is generally not occluded by the leading edge of the posterior facet of the talus.

On the dorsoplantar view the normal talocalcaneal angle is approximately 18 degrees.[9,17,20] In the pronated foot type the dorsal plantar talocalcaneal angle is generally greater than 28 degrees, the lateral talocalcaneal angle generally greater than 50 degrees, the talar declination angle usually greater than 26 degrees, and the talar first metatarsal angle is negative with the bisection of the talus passing plantar to the first metatarsal head. The sinus tarsi is generally occluded by the anterior edge of the posterior facet of the talus.

Neutral position x-rays are often utilized to better evaluate the flexible flatfoot. The dorsal plantar and lateral x-rays are taken with the foot held in a neutral subtalar joint stance position. This will help to demonstrate the flexible nature of the foot and the potential

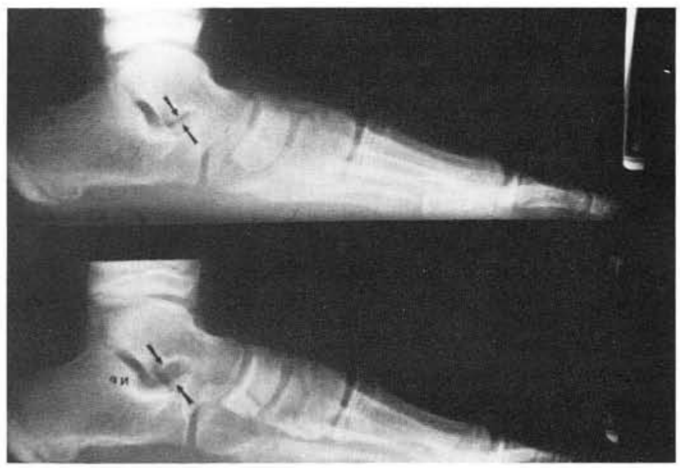

Fig. 7A. Lateral view relaxed stance position vs. neutral stance position.

Fig. 7B. DP view relaxed stance position vs. neutral stance position.

position of function postoperatively. Generally the talar declination angle will decrease, the sinus tarsi will open, and there will be a lower talocalcaneal angle. Furthermore, transverse plane deformities such as metatarsus adductus will be demonstrated with greater clarity (Fig. 7A,B).

EXPECTATIONS

It is very important for the parents and patient to understand the reasonable expectations of the surgery. 1) One wishes to do no harm with the surgical correction. Consequently under-correction may be noted postoperatively. 2) The patient should be left with some ability to pronate, but it should be much more mild than that seen preoperatively.[42] Preoperative photographs are taken for reference. 3) The patient's parents as well as the patient are told of the continued need for functional orthotics after the surgery. A perfect foot can not be expected, however, the improvement should be gratifying both clinically and radiographically.[24,25] They should also expect to have a more adducted gait pattern than previously had been noted. This is due to the forefoot being adducted into a more anatomic position relative to the talus (and leg). If there is a metatarsus adductus component, one may tend to develop shoe irritation medially after surgery. This must be closely evaluated preoperatively.

Relative contraindications to surgery include 1) the rigid, non-reducible flatfoot, 2) significant super-structural deformity such as severe medial or lateral torsional problems, 3) severe uncontrollable pronatory forces that are left untreated such as a severe gastro-soleus equinus, 4) neuromuscular disease, 5) tarsal coalitions, 6) arthritis, 7) morbid obesity, and 8) age. The authors would not recommend this procedure on individuals under 4 years of age prior to adequate maturity of the neurologic and musculoskeletal systems. Although the STA-peg arthroereisis has been used in adults, its most efficient and effective utilization is in the growing child. The modification of the STA-peg arthroereisis limits excessive subtalar joint pronation and subluxation by blocking the anterior lateral wall of the body of the talus as it adducts and moves forward to occlude the sinus tarsi. This is in contradistinction to the more traditional STA-peg arthroereisis that limits the forward and downward excursion of the leading edge of the posterior facet of the talus. This may prove a more effective means of controlling the transverse planae dominant foot type[19] (Fig. 8A, B, C).

Intraoperatively, alignment markers are made on the anterior aspect of the leg and dorsum of the foot with the foot held in the neutral subtalar joint position. A second

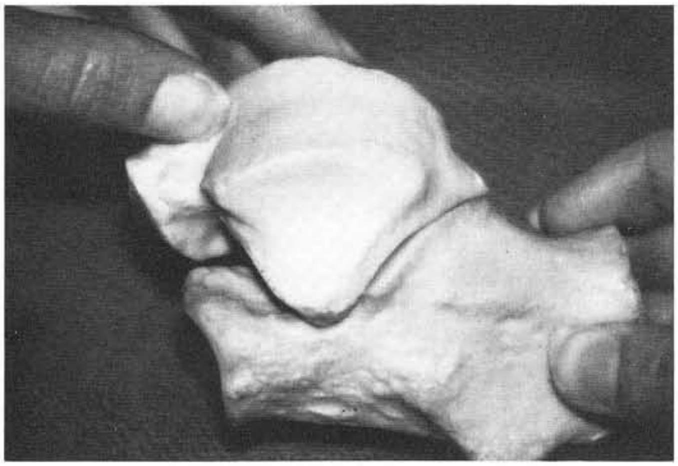

Fig. 8A. Bone model with pronated subtalar joint demonstrating the occlusion of the sinus tarsi by the leading edge of the posterior facet of the talus.

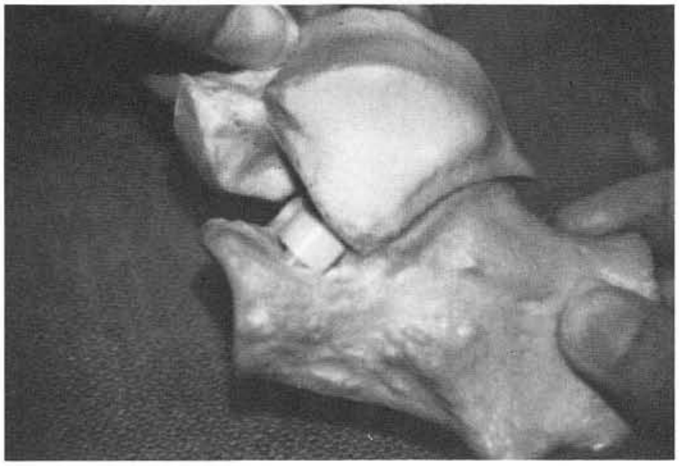

Fig. 8B. With STA-peg in place the forward excursion of the leading edge of the posterior facet of the talus (pronation) is limited.

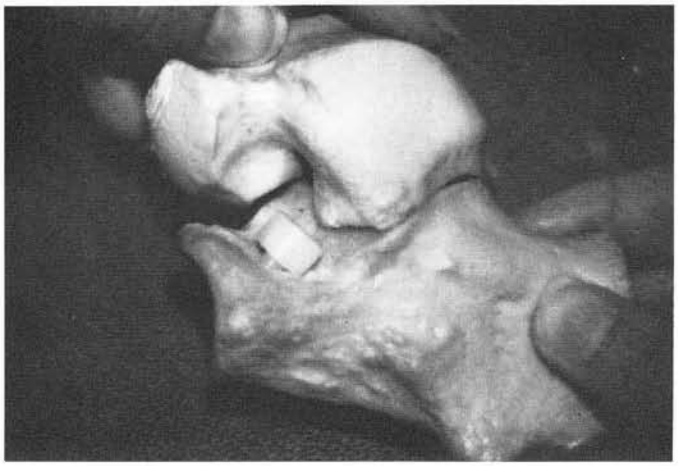

Fig. 8C. Posterior excursion (supination) is not limited.

line is made on the foot with the foot held in a maximally pronated position. (Fig. 9A). The correction should be such that the foot in a maximally pronated position lies between these two lines, but closer to the neutral position than the maximally pronated alignment.

Next, the lateral aspect of the foot is evaluated; the peroneal tendons are marked and the intermediate dorsal cutaneous nerve is identified (Fig. 9B). A modified

Fig. 9A. Lateral radiographs
relaxed stance position preoperative
neutral stance position preoperative
relaxed stance position postoperative STA-peg

Fig. 9B. Dorsal plantar radiographs
relaxed stance position preoperative
neutral stance position preoperative
relaxed stance position postoperative STA-peg

Ollier incision is then made parallel with the skin lines over the sinus tarsi between the anatomic markers. The subcutaneous tissue is reflected and the deep fascia is identified. Care is taken to ensure that the sural nerve is not involved in this incisional approach. An L shaped incision is made through the deep fascia which is reflected distally and inferiorly exposing the sinus tarsi. The plug of the sinus tarsi is cleared and the posterior facet of the subtalar joint is identified. The width of the template corresponds to the width of the medium and small size straight STA-peg. This template is utilized to determine the position and size of implant that is desired (Fig. 10A). It is aligned so as to parallel the leading wall of the posterior facet of the talus in its most pronated position. The talus is supinated and a sharp awl is introduced into the center opening of the template to mark the position in the calcaneus where the stem of the implant will be seated (Fig. 10B). The angulation and direction of that stem is identified. The hole in the floor of the sinus tarsi is widened and deepened with curved hemostats and a sharply ridged awl (Fig. 10C). The spacer is then seated in the calcaneus and trial fitting is accomplished. The leading wall of the posterior facet of the talus should hit flush against the STA-peg itself. If it is difficult to secure this position then methyl methacrylate may be required to "cement" the STA-peg (Fig. 10D). The spacer is removed and the appropriately sized implant is secured in place. If methyl methacrylate is used hemostats are utilized in the peg hole to widen the area underneath the cortex to allow for some spreading of the material. A very small amount is used in the peg hole and the STA-peg is secured in place by pronating the talus against the border of the STA-peg while the methyl methacrylate hardens. The wound is flushed with normal saline. It is essential that no soft tissue remain between the STA-peg and the lateral talar process (Fig. 10E). The fascial tissue is then re-approximated over the STA-peg utilizing 3.0 simple interrupted absorbable sutures. The wound is closed in anatomic layers, using a 4.0 continuous interlocking absorbable suture and a 5.0 subcuticular stitch. Generally, a local anesthetic is infiltrated in the area to help curb immediate postoperative discomfort.

ANCILLARY PROCEDURES

Ancillary procedures may be indicated with the STA-peg depending upon the nature of the deformity. If there is a limitation of ankle joint dorsiflexion then tendo-Achilles' lengthening or a gastrocnemius recession may be required. In the older child and those with more severe subluxation, a medial arch reconstruction may be helpful. Older patients with severe medial column instability may benefit from the Hoke or Miller procedures.

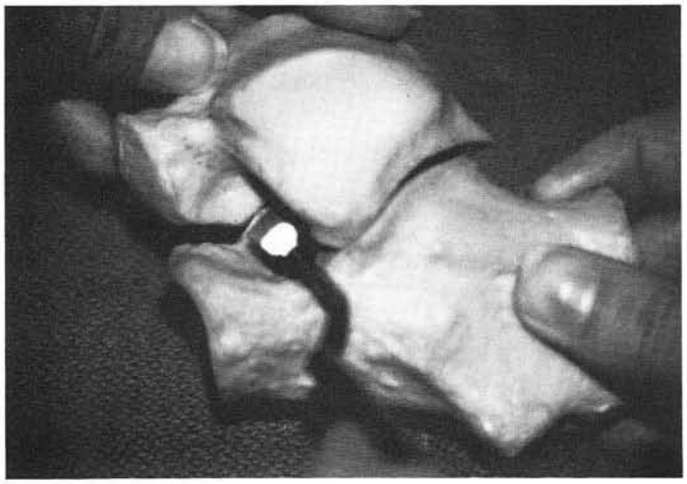

Fig. 10A. Template is used in sinus tarsi to determine size and location of the STA-peg.

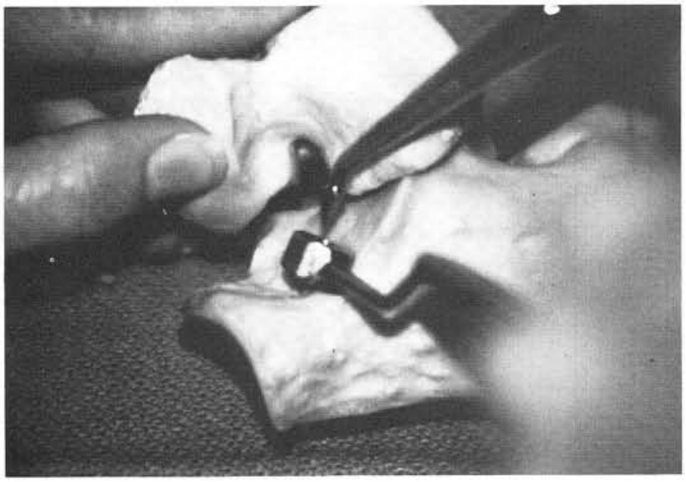

Fig. 10B. Location of hole in calcaneus is marked with a sharp awl through the hole in the template.

Fig. 10C. The hole is widened to accommodate the sizer.

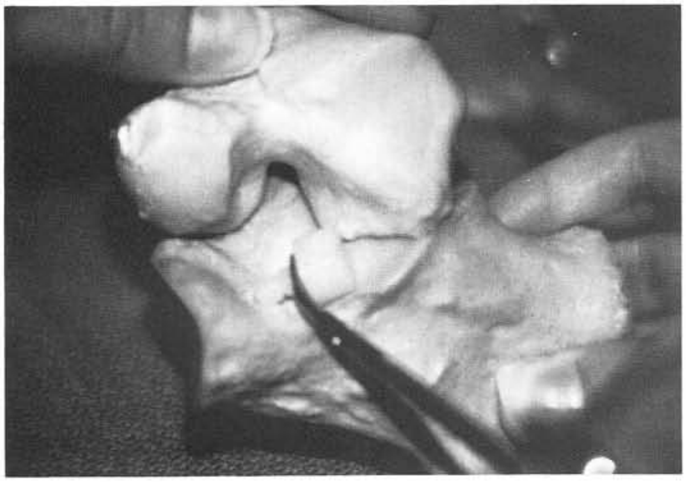

Fig. 10D. Methyl Methacolate is used if necessary to allow the flush contact between the STA-peg and the lateral wall of the talar body.

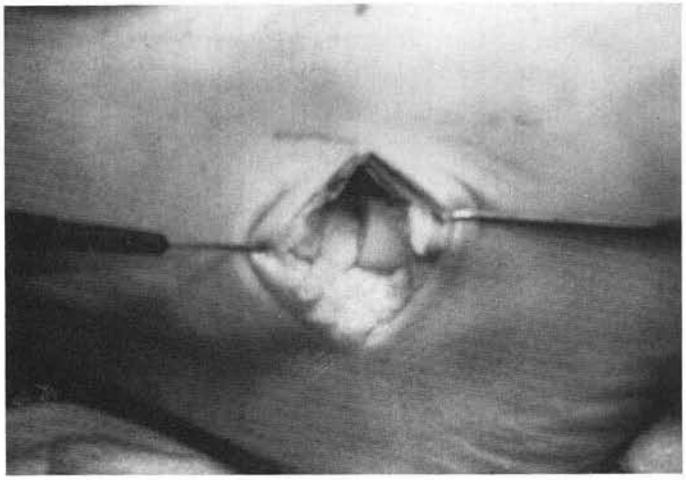

Fig. 10E. Clinical picture of the STA-peg is in place and blocking the forward progression of the lateral wall of the talar body.

POSTOPERATIVE COURSE

The postoperative course involves immediate weight bearing with surgical shoes and a compression bandage for 2 weeks. Early range of motion is encouraged. The patient may begin wear with a soft soled shoe at about 2 weeks postoperatively. Peroneus longus strengthening exercises are initiated before surgical intervention and are an essential part of the postoperative course. The patient is not allowed to run or jump for 3 months and sports activities that require vigorous foot mobility or stress may be limited for 5-6 months.

RESULTS

The authors are currently in the process of evaluating 28 patients who have undergone the modified STA-peg procedure over the past 7 years. This represents a total of 51 feet, each 2 years or longer following surgery. Subjective reports have been collected from most of these patients, preoperative x-rays on all of them, and long term x-rays on many. At the time of this writing the authors have complete results on 6 children representing 12 feet, and 4 adults representing 5 feet. This is approximately 33% of the targeted patients. The children are all essentially asymptomatic. All of the patients were involved in normal sports activities. One patient occasionally has sinus tarsi pain with prolonged running. She was so significantly improved from her symptoms preoperatively that this was of little consequence to her. There was an adjunctive Kidner procedure on 1 foot in 2 different children. The ages range from 5 to 13.

The adults range in age from 27 to 69 with an average follow up of between 2-3 years. One of the individuals previously had a Sgarlato silastic implant that had broken. He was improved with the STA-peg, but continues to suffer from some arthritis. One individual had a talonavicular fusion along with the STA-peg which limited motion and reduced the foot pain approximately 70%. The adult who had bilateral STA-pegs was 50% improved, but refused to wear functional orthotics. The final patient had an ancillary Kidner procedure and was 80% improved. The opposite foot was now limiting his ambulation.

Overall the lateral talocalcaneal and talar declination angles were reduced. The talar first metatarsal angle approximated 0 degrees compared to the negative values preoperatively. The sinus tarsi was noted to be more anatomic in its appearance. On the dorsoplantar view, the talocalcaneal angle was similarly reduced.

POTENTIAL COMPLICATIONS

1) Overcorrection can be a significant problem if the patient is not able to evert 4 to 5 degrees beyond the perpendicular. This can lead to localized or postural symptoms similar to those associated with an uncompensated rear foot varus. 2) Under correction - the authors tend to under-correct a slight amount since a foot that may be mildly pronated can usually be well controlled with functional orthotics. However, inadequate correction may not prevent severe pronation from occurring as the individual grows. 3) There can be sinus tarsi pain secondary to reactive synovitis, soft tissue entrapment, or nerve entrapment. 4) A peroneal spastic flatfoot may develop. 5) Loosening or fragmentation of the implant may occur, although this has yet to be seen in our study to date. 6) There can be fracture of the talus or the calcaneus, or erosion of the bone implant interface. 7) Implant depression and subluxation into the calcaneal cuboid joint may occur. 8) There can be degenerative arthritis, infection, hepatitis, biomaterial failure, inappropriate application of the implant itself, or a surgical misadventure.

To date these complications have not been evident in those patients we have been able to evaluate 2 to 7 years postoperatively. There is occasional transient sinus tarsi pain, but this seems to resolve with range of motion and strengthening exercises. There have been no reported cases of loosening or fragmentation of the implant. In the one adult who had arthritis preoperatively, talonavicular fusion and the STA-peg arthroereisis had reduced the arthritic pain in his foot about 70%.

One patient that developed a peroneal spasm and pain has not been included in our study since the postoperative period is less than 2 years. This happened in a 6 year old male who was playing soccer and injured his foot at 5 months following surgery. From that point gradual peroneal spasm and pain developed. The STA-peg operation was performed bilaterally and this only affected his right foot. Conservative therapy failed to relieve the symptoms and re-exploration of the area was undertaken approximately 1 year postoperatively. At the time of surgery a ledge of talar bone was identified in the proximity of the medial or deep border of the STA-peg implant. This ridge of bone corresponded to the medial deep wall of the STA-peg and was approximately 2 mm. in length. This exostotic wall was removed and smoothed. The implant remained secure in satisfactory position and was not disturbed. The wound was closed and at the present time, four months later, the patient is asymptomatic.

In conclusion, the preliminary review of the STA-peg arthroereisis via blocking the anterior lateral wall of the talar body seems to produce similar rewarding results to the Smith and Lundeen series. The advantage of blocking the excessive range of pronation in the growing child while allowing more normal function to the remaining pedal joints is an exciting prospect. Although any surgical procedure carries with it some inherent risks, the STA-peg seems to have performed well in this study. No fusion of joints is required, stress on adjacent joints is minimized, and normal motion is preserved. If complications arise, removal of the implant will usually eliminate the problem. In our attempt to do no harm to the growing child, this procedure has had relatively few complications. Our modification of the Smith STA-peg may have the additional advantages of avoiding an implant cartilage interface and better control in transverse plane dominant foot types.

References

1. Addante J, Ioli J, Chin M: Silastic Sphere Arthroereisis for surgical treatment of flexible flatfoot. *J Foot Surg.* 21 (2):91-95, 1982
2. Baker I, Hill L: Foot Alignment in the Cerebral Palsy Patient *J Bone Joint Surg* 46A: 1964
3. Beck E, McGlamry E: Modified Young Tenosuspension Technique for Flexible Flatfoot. *J Am Podiatry Assoc* 63: 1, 1973.
4. Chambers EFS: An Operation for the Correction of Flexible Flatfoot of Adolescents. *West J Surg Obstet Gynecol* 54:77-86, 1946.
5. Ce J, Inman VT: The Action of the Subtalar Joint. *Prosthetic Devices Research Project,* Series 11, issue 24, Institute of Engineering Research, Univ. of Calif., Berkeley, 1953
6. Close JR, Inman VT, Poor PM, Todd FN: The Function of the Subtalar Joint. *Clin Ortho* 50:150, 1967.
7. *Dorland's Illustrated Medical Dictionary* - 24th Edition. WB Saunders Co, Philadelphia, p. 146, 1965.
8. Dennyson WG, Fulford GE: Subtalar Arthrodesis by Cancellous Grafts and Metallic Internal Fixation. *J Bone Joint Surg* 58-B:507, 1976
9. DiGiovanni JE, Smith SD: Normal Biomechanics of the Adult Rearfoot. *J Am Podiatry Assoc* 66:11, 1976
10. Duchenne GB: *Physiology of Motion* Philadelphia, WB Saunders, Philadelphia, 1959.
11. Dwyer FC: Osteotomy of the Calcaneus for Pes Cavus. *J Bone Joint Surg.* 41B:80-86, 1960
12. Evans D: Calcaneus Valgus Deformity. *J Bone Joint Surg* 57B:270-278, 1975.
13. Feinstein P: Orthopedic Management of Three General Types of Symptomatic Flatfoot. *Ortho Review* 8(5), 1979.
14. Gamble FO, Yale I: *Clinical Foot Roentgenology.* Williams & Wilkins, Baltimore, 1966.
15. Ganley J: Calcaneovalgus Deformity in Infants. *J Am Podiatry Assoc* 65:5, 1975.
16. Gleich A: Bierag zue Operativen Platt Fuss Behandlung. *Arch Klin Shir* 46:358, 1893.
17. Green D, Sgarlato T, Wittenberg M: Clinical Biomechanical Evaluation of the Foot. *J Am Podiatry Assoc* 65:8, 1976.
18. Green D, Whitney A, Walters P: Subtalar Motion A Simplified View. *J Am Podiatry Assoc* 69:83, 1979.
19. Green D, Carol A: Planal Dominance. *J Am Podiatry Assoc* 74:98, 1984.
20. Green D et al: The Foot in Motion, A radio-cinematographic Study (Movie) American Podiatric Medical Association, Audiovisual Library, Washington, D.C.
21. Grice D: An Extra-Articular Arthrodesis of the Subastragalar Joint for Correction of Paralytic Flat Feet in Children. *J Bone Joint Surg,* 37-A:927 1952.
22. Grice D: Further Experience with Extra-Articular Arthrodesis of the Subtalar Joint. *J Bone Joint Surg,* 37-A:246, 1955.
23. Grice D: The Role of Subtalar Fusion and the Treatment of Valgus Deformities of the Feet. *Am Acad Orthop Surg* (instructional course lectures), 16:127, 1959.
24. Haraldsson S: Operative Treatment of Pes Planovalgus Staticus Juvenilis. *Acta Orthop Scand* 32:492, 1962.
25. Haraldsson S: Pes Planovalgus Staticus Juvenilis and Its Operative Treatment. *Acta Orthop Scand* 35:234, 1965.
26. Harris R, Beath T: Hypermobile Flatfoot with Short Tendo-Achilles. *J Bone Joint Surg,* 30A:116, 1948.
27. Hicks J: The Mechanics of the Foot. *I Joints J Anat* (London) 87:345, 1953.
28. Hicks J: The Mechanics of the Foot. II. The Plantar Aponeurosis and the Arch *J Anat* (London) 88:24, 1954.
29. Hicks J: The Foot as a Support. *Acta Anat* 24:34, 1955.
30. Hoke M: An Operation for the Correction of Extremely Relaxed Flat Feet. *J Bone Joint Surg* 13:773, 1931.
31. Inman V: *The Joints of the Ankle.* Williams & Wilkins, Baltimore, p.35, 1974.
32. Jack E: Navicular-Cuneiform Fusion in the Treatment of Flatfoot. *J Bone Joint Surg* 35B 1, Feb, 1953.
33. Kidner F: The Prehallux (accessory scaphoid) in Its Relation to Flatfoot. *J Bone Joint Surg* 11:831, 1929.
34. Kidner F: The Prehallux in Relation to Flatfoot. *JAMA* 101: 1539, 1933.
35. Kirby K: Methods for Determination of Positional Variations in the Subtalar Joint Axis. *J Am Podiatr Med Assoc* 77:228, 1987.
36. Kelinberg S, Roth F: The Operative Correction of Flatfeet in Children. Bulletin, Hospital for Joint Diseases 8(2), Oct 1947.
37. Koutsogiannis E: Treatment of Mobile Flatfoot by Displacement of Osteotomy of Calcaneus. *J Bone Joint Surg* 53B:96, 1971.
38. Lahdenranta U, Pylkkanen P: Subtalar Extra-Articular Fusion in the Treatment of Valgus and Varus Deformities in Children. *Acta Orthop Scand* 43:438, 1972
39. Langford J, Bozof J, Horowitz B:Subtalar Arthroereisis, Valente Procedure. *Clin Pod Med Surg* 4(1): 153-61, 1987.
40. Lanham R Jr: Indications and Complications of Arthroereisis in Hypermobile Flatfoot. *J Am Podia-*

try Assoc 69:178, 1979.
41. Leavitt D: Subastragaloid Arthrodesis for the Os Calcis Type of Flatfoot. *Am J Surg* 59(3): 501, 1943.
42. LeLievre J: The Valgus Foot: Current Concepts and Correction. *Clin Orthop* 70:43-55, 1970.
43. Lord J: Correction of Extreme Flatfoot. Values of Osteotomy of Os Calcis and inward Displacement of Posterior Fragment. *JAMA* 81:1502, 1923.
44. Lowman C: An Operative Method for Correction of Certain Forms of Flatfoot. *JAMA* 81:1500, 1923.
45. Lundeen R: The Smith STA-peg Operation for Hypermobile Pes Planovalgus in Children. *J Am Podiatr Med Assoc* 75:4, 1985.
46. Manter J: Movements of the Subtalar and Transverse Tarsal Joints. *Anat Rec,* 80:397, 1941.
47. Milch H: Reinforcement of Deltoid Ligament for Pronated Flatfoot. - Inversion Fasciodesis of Os Calcis. *Surg Gynecol Obstet* 74:876, 1942.
48. Miller O: A Plastic Flatfoot Operation. *J Bone Joint Surg* 9:84, 1927.
49. Nove-Josserand G: Artroise of Foot *J Bone Joint Surg* 10:261-267, 1928.
50. Ogilvy C: An Operation for the Permanent Correction of Weak Feet in Children. *J Ortho Surg* 1:343, 1919.
51. Phillips G: A Review of Elongation of Os Calcis for Flat Feet. *J Bone Joint Surg* 65(B)1, 1983.
52. Philips RD, Christe R, Phillips RL: Clinical Measurement of the Axis of the Subtalar Joint. *J Am Podiatry Assoc* 75:119, 1985.
53. Root M, Orien W, Weed J: *Normal and Abnormal Function of the Foot.* Clinical Biomechanics Corporation, Los Angeles, 1977.
54. Ryerson E: Arthrodesing Operations on the Feet. *J Bone Joint Surg* 5:453, 1923.
55. Samuelson K, Tuke M, Freeman M: A New Reconstructive Procedure to Correct Hindfoot Valgus. *Orthop Trans* 4:147, 1980.
56. Schoolfield B: Operative Treatment of Flatfoot. *Surg Gynecol Obstet* 94:136, Jan-June 1952.
57. Schoenhaus H: The Schoenhaus Plug. in Mercado OA (ed) *An Atlas of Foot Surgery, Vol II, Rearfoot Surgery,* Carolando Press, Inc., Oak Park, IL, p 207-210, 1987.
58. Schuster O: *Foot Orthopaedics.* The First Institute of Podiatry, New York, p. 69-74, 1927.
59. Selakovich W: McDial Arch Support by Operation, Sustentaculum Tali Procedure. *Orthop Clin North Am* 4(1) Jan 1973.
60. Silver C, Simon S, Spindell E, Litchman H, Scala M: Calcaneal Osteotomy for Valgus and Varus Deformities of the Foot in Cerebral Palsy. *J Bone Joint Surg* 49A:232, 1967.
61. Silver C, Simon S, Litchman H: Long Term Follow Up Observations on Calcaneal Osteotomy. *Clin Orthop* 99: March/April, 1974.
62. Smith S, GiGiovanni J,(eds),: *Decision Making in Foot Surgery.* Stratton Intercontinental Medical Book Corp., New York, p. 101-207, 1976
63. Smith S, Millar E: Arthroereisis by Means of a Subtalar Polyethylene Peg Implant for Correction of Hindfoot Pronation in Children. *Clin. Orthop* 181, 1983.
64. Soule R: Value of Bone Pin Arthrodesis in the Treatment of Flatfoot. *JAMA* 77(24):1871, 1921.
65. Subotnick S: The Flexible Flatfoot. *Arch Pod Med Foot Surg* 1(1), 1973.
66. Subotnick S: The Subtalar Joint Lateral Extra-Articular Arthroereisis; A Preliminary Report. *J Am Podiatry Assoc* 64:701-711, 1974.
67. Subnotick S: The Subtalar Joint Lateral Extra-Articular Arthroereisis: A Follow Up Report. *J Am Podiatry Assoc* 67:151, 1977.
68. Vogler H: Silastic Canalis Tarsi Implant. Arthroereisis: Principles and Concepts, in Levin W (ed) *Hershey Update* Pennsylvania Podiatry Association, Camp Hill, Pennsylvania, 1:15, 1981.
69. Vogler H: Subtalar Joint Blocking Operations for Pathological Pronation Syndromes. in McGlamry ED (ed) *Comprehensive Textbook of Foot Surgery,* Williams & Wilkins, Baltimore, p. 447-465, 1987.
70. Wilson H, Patterson R: The Combined Operation of Arthrodesis and Transplantation of the Tendon of the Extensor Proprius Hallucis for the Relief of Flatfoot. *Am Med* May, Vol IX Jan-Jun, 1905.
71. Wright D, Desai S, Henderson W: Action of the Subtalar and Ankle Joint Complex During the Stance Phase of Walking. *J Bone Joint Surg* 46A:361, 1964.
72. Young C: Operative Treatment of Pes Planus. *Surg Gynecol Obstet* 68:1099-1101, 1939.