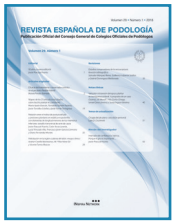

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UPDATES
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Flatfoot surgery: a personal view

Cirugía del pie plano: una visión personal

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Palabras clave:

Pie plano, pie plano pediátrico flexible, pie plano adquirido del adulto, artroeresis, osteotomía de Evans, osteotomía de Cotton, osteotomía de calcáneo de desplazamiento medial, rigidez de la columna interna.

Resumen

Existen diferentes opciones para la corrección quirúrgica del pie plano, y la aplicación de una u otra técnica en un paciente concreto puede estar muy influenciada por la experiencia previa del cirujano, su educación/entrenamiento y/o sus preferencias personales. Un profundo entendimiento de la influencia biomecánica relacionada con el pie plano y de las diferencias conceptuales en los distintos abordajes para la corrección de las fuerzas patológicas es fundamental. Existen muchas combinaciones de técnicas que pueden ofrecer resultados satisfactorios y es recomendable para todos los cirujanos estar familiarizados con todos estos procedimientos para adecuar la selección de los mismos en cada paciente concreto. El presente artículo aúna la bibliografía reciente más relevante sobre la corrección del pie plano junto con la experiencia personal del autor para el tratamiento quirúrgico esta deformidad por más de 25 años.

Keywords:

Flatfoot, pediatric flexible flatfoot, adult adquired flatfoot, arthroereisis, Evans osteotomy, Cotton osteotomy, medial calcaneal displacement osteotomy, medial column stiffness.

Abstract

The options for the surgical correction of flatfeet are varied and can be significantly influenced by a single surgeons experience and tendencies. An intimate understanding of the biomechanical influences that lead to flatfeet and the varied conceptual approaches to the correction of these forces is fundamental. There are many combinations of procedures that can result in satisfactory outcomes and it is wise for all surgeons to be familiar with as many as possible to tailor the procedural selection to each individual patient. This article encompases the most recent and relevant literature with the personal experience of the author for the surgical treatment of flatfoot deformity

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INTRODUCTION

"Medicine is a science of uncertainty and an art of probability" stated Sir. William Osler, the founding father of the American residency model of post graduate training. This mix of art and science pervades flatfoot surgery as well and in spite of evidence based medicine initiatives of the last 15 years flatfoot surgery remains more art than science. The most effective flatfoot surgeon would need to be intimately familiar with all aspects of the management of clubfeet, actively engaged in the regular clinical care of the full range of patients from pediatrics to adults with flatfoot complaints, be married with multiple children of their own and equally expert in the non-operative management of symptomatic flatfeet. Likely this ideal surgeon does not exist.

Why clubfeet? Because the opposites in life define each other and there is much to be learned from the deforming forces of talipes equinovarus that can be applied to the appreciation of the development of the flatfoot deformity. Why pediatrics to adults? Because only be seeing a continuum of patients with varying degrees of symptomatic and non-symptomatic flatfeet can one appreciate completely when interventions are necessary or not and how they affect function and quality of life parameters. Married with multiple children of your own?? What does this have to do with anything?! My observations over 25 years of worldwide surgical practice in over 20 countries is that full empathy and objective consideration of patients with flatfeet can only be optimized by observing your own children's development. This includes engaging in the necessary conversations with an equally concerned spouse regarding to treat or not to treat while watching 24 hours / 7 days a week year after year the natural progression and growth of your offspring and the recognition that no two children are exactly the same. An expertise in orthotics and non-operative management of pathologic flatfeet is essential in the appreciation of all that can be improved functionally without ever doing any surgery at all.

THE DEFORMITY

I had the enormous privilege of doing my very first clinical rotation as a podiatric medical student at the Pennsylvania College of Podiatric Medicine in May 1989 in the office of Dr. James V. Ganley, the founding father of American podopediatrics and the first podiatric popularizer of the use of the Evans calcaneal osteotomy. He explained to me that he had written a short play entitled "Terrible Mr. Talus" and discussed how a trap door in the stage floor would open and Mr. Talus would drop through, analogous to the abduction of the calcaneus and sustantaculum tali that allow the plantar and medial migration of the talar head and neck in a flatfoot deformity. He also had completed a study confirming that the calcaneus does not evert past perpendicular in pediatric flatfeet yet rather what appears as eversion of the heel is really abduction of the calcaneus. His further significant interest and publication was on congenital calcaneovalgus and he was a frequent prescriber of casting of this deformity in infants to reduce its risk as a precursor of a pediatric flatfoot deformity. When was the last time you heard of anyone speaking of casting infants to correct the deformity of calcaneus valgus?

The clubfoot deformity of talipes equinovarus serves as a very useful model to fully understand the progressive deformity of flatfeet. In a still born dissection of a congenital clubfoot. (figure 1) It is apparent that the talus is squarely seated in the ankle mortise and the deformity is the resultant spinning of the foot medially and plantarly around the talus. The talus is only passively involved in foot deformities as it has no tendinous attachments of its own. Essentially the anterior, posterior, medial and lateral extrinsic muscle compartments serve as muscular pulleys through their tendinous attachments to the foot bones and the bones shift in relation to one another via the intact ligamentous constraints. The talus belongs to the leg and the foot bones are a foot plate that is maintained in its undeformed state by the very architecture of the bones and the close packed configuration of these joints with their intact ligaments. In flatfeet the opposite deformity occurs and instead of spinning medially the foot plate of a flatfoot spins and rotates laterally away from and underneath the talus and the talus drops into a medial and plantar flexed position. Deformities progress as ligaments attenuate or rupture and the osseous components continue to further displace. This results in the change of vectors and moments of tendinous pull which upsets the balance between agonists and antagonists of extrinsic muscles which then further defines the severity and rigidity or lack thereof the flatfoot deformity. When all functions well an intact windlass mechanism and stable medial column allow for normal foot kinematics and normal gait. When there is a failure in stability of the medial column it typically fails through the navicular cuneiform joint as the foot plate twist or untwists via supination and pronation of this joint.

Figure 1. Still born dissection of a clubfoot.

THE TREATMENT

The truest art of flatfoot surgery is procedural selection like an artist must pick colors from a palette. One size does not fit all and there are many options available. A surgeons personal training, their teachers influence plus their skill level as well and knowledge of current literature all influence the effective communication to patients of realistic expectations that lead to satisfactory outcomes. A prudent general principle for surgery is to do "the least possible while simultaneously doing the most necessary". The procedural selection and the "when" and "why" and "how" of surgical interventions are varied and challenging. It is generally understood that many people function just fine with flatfeet and a personal philosophy is that flatfoot surgery should only be undertaken when there is truly a painful condition that is affecting quality of life. The typical activities of daily living must be altered while also non responsive to conservative care. In general, it is best to observe children with flexible flatfeet up to the age of 10 years old. There is a great need for the surgical interventions when necessary to be definitive and there seems to be an excessively high rate of revisional flatfoot surgery. I believe that many surgeons stick to only the procedures that they are comfortable performing which is a solid principle but yet can lead to poor outcomes in cases where their favorite procedure was inadequate for a specific patient.

Procedural selection has typically revolved around concepts of the flexibility of the deformity and the columnar approach to the medial column versus the lateral column. The concepts of essential versus non-essential joints popularized by Sigvard Hansen figure prominently into decision making as well. There are great summary articles and chapters on the options for flatfoot surgical correction and the intent is not to duplicate those in this article.(1) Rather the aim is to articulate a thought process as to why and what is to be done and when one procedure is indicated more than another while sharing the most recent literature available that has advanced our knowledge and improved our procedural selection.

The simplest way to determine the flexibility or reducibility of a symptomatic flatfoot deformity in a weight bearing fashion is to neutralize any deforming force of equinus by having the patient take a single step forward and attempt to activate the windlass mechanism of the medial arch. (figure 2) This serves reliably well to determine if indeed the close packed configuration of the medial column joints can be achieved and procedural selection proceeds from there. Xrays may be taken in the AP and lateral projections to serve as a template for intraoperative planning. The theories of planal dominance as it relates to procedural selection in flatfoot deformity suggest that those flatfeet with more frontal plane dominance necessitate subtalar joint arthroeresis or calcaneal displacement osteotomies, those with more transverse plane deformity necessitate the Evans lateral column lengthening procedure and those with more sagittal plane dominance require a medial column fusion. I have largely abandoned this approach except in severely exaggerated cases of forefoot abduction which tend to indicate the use of the Evans lateral column lengthening.

The "columnar approach"

The columnar approach to flatfeet essentially dictates that the lateral column is subjected to compressive forces and the medial column is subjected to distraction forces. The goal of course is to reverse these forces. It has been this author's observation that where many surgeons reflexively go directly to the combination of the Evans calcaneal and cotton medial cuneiform osteotomies as their standard choice of procedures, it is wisest to seek to determine if an extra osseous talotarsal stabilization (arthroeresis) procedure is an option before considering any other procedures. It is the least invasive, reversible if necessary and essentially an internal orthotic. Although the Evans – Cotton combination is tried and true (figure 3) we have also learned that the arthroeresis is equally effective and corrects the flexible flatfoot deformities in all 3 planes.(2) There is even further recent support for calcaneo-stop implants and innovative research on extraosseous talotarsal stabilization including in adult acquired flatfoot models. Arthroeresis implants lower plantar pressures and strain of medial ligaments that support the medial arch and can shift the load of the medial column to the lateral column.(3,4) A general indication for extraosseous stabilization is completely reducible flexible flatfeet in adolescent flatfoot surgery in children between the ages of 4 to 16 years old that are not excessively obese and do not have excessively high calcaneocuboid abduction angles on clinical exam or radiographic parameters. (figure 4,5) An additional reason for always considering arthroeresis as the first choice option is a long held personal suspicion that lateral column procedures might not even be necessary to correct flatfeet if the medial column is adequately stabilized. Literature suggests this may

Figure 2. The "one step forward" test to confirm flexibility of a flatfoot while negating the effect of equinus.

be true as well. (5) After all, there is no intrinsic deformity within the actual calcaneal bone itself and as previously discussed the foot plate has simply rotated out from under and away from the talus. Although this will be discussed later, essentially the medial column is like the kickstand of a bicycle and if stably and rigidly on the ground is capable of preventing the entire foot from falling over. We see this opposite effect routinely in the ability of a rigidly plantar flexed first ray in a cavus foot to tip the heel into a varus deformity. Arthroeresis is not a procedure without potential although they are infrequent and almost always due to surgeon error during implantation of the device. (figure 6)

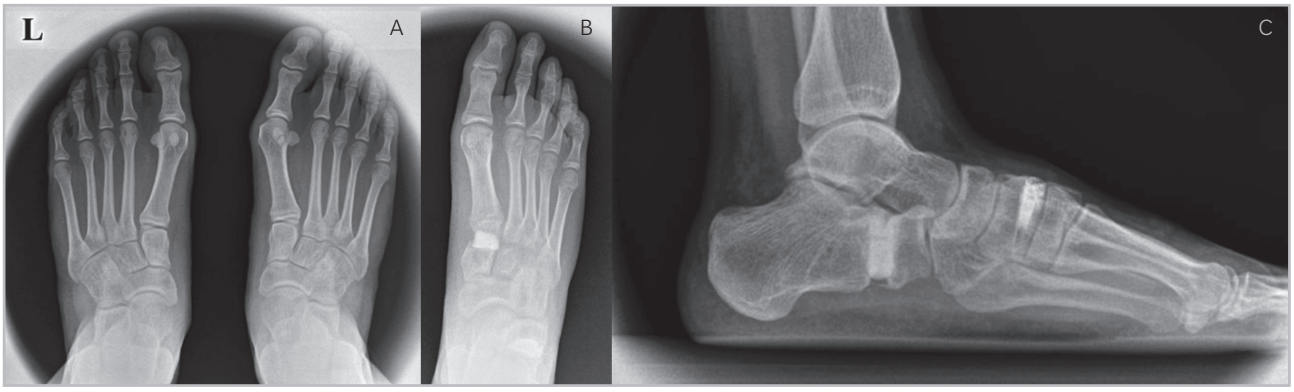

Figure 3. A. Right flatfoot preop; B and C. Postop AP and Lateral demonstrating correction via Evans and Cotton osteotomies.

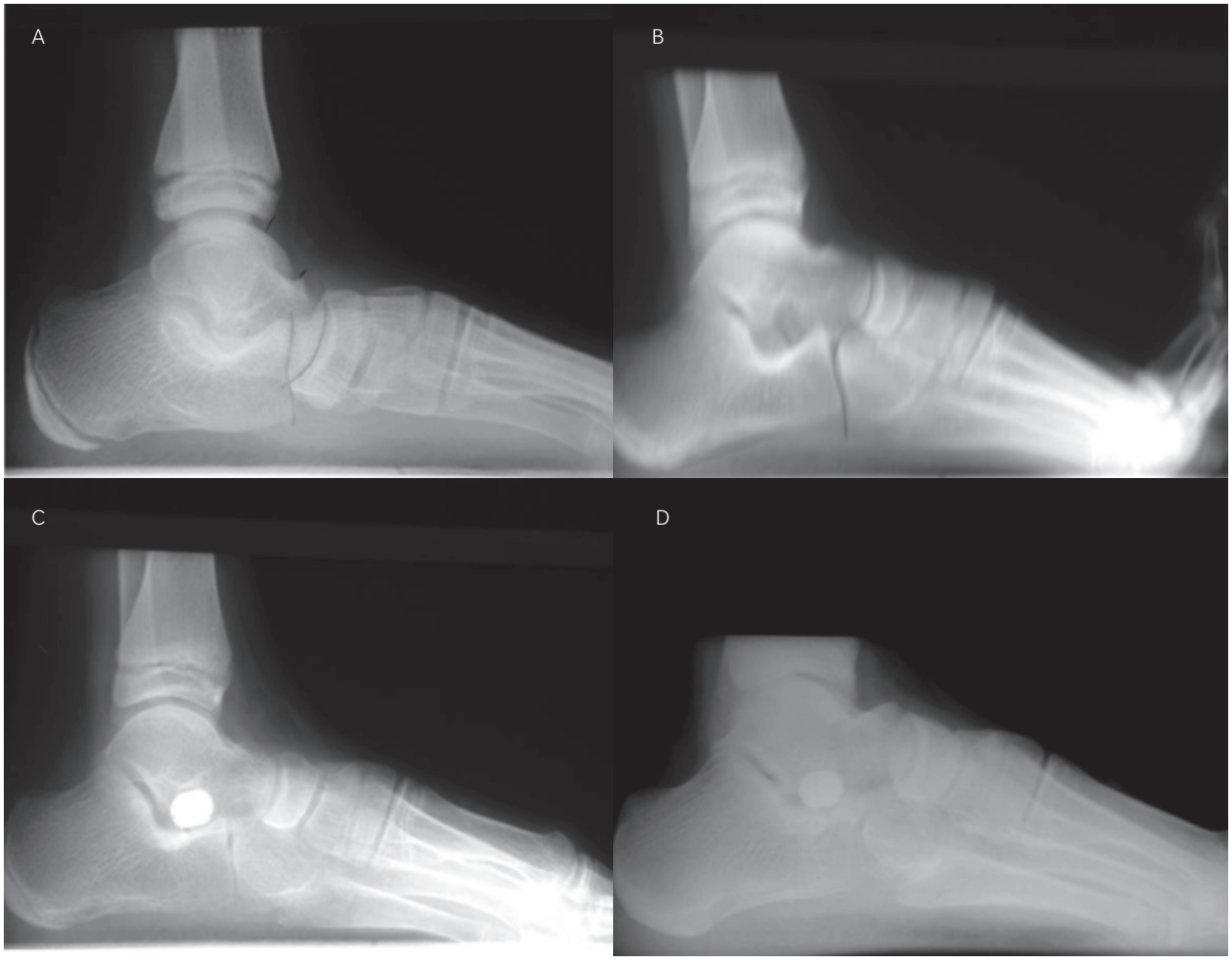

Figure 4. A. Preop lateral xray. B. Preop neutral position lateral xray. C. Postop lateral xray. D. Postop lateral xrays 6 years postop.

Figure 5. A. Preop clinical of 4 year old child. B. Postop clinical of same child at 1 month postop.

Figure 6. Postop lateral xray 7 years postop after iatrogenic placement of a subtalar implant that caused arthritic changes to the subtalar joint.

When procedural selection does indicate that the lateral column compressive forces are most likely best served by an osseous procedure the two most common options are the Evans calcaneal lengthening procedure or the medial calcaneal displacement or Z calcaneal osteotomy procedure. The ability of the Evans procedure to improve the mechanical pull of the peroneus longus and re-cover the talar head with the navicular are well understood for ages now. The medial calcaneal displacement osteotomy gained more popularity in the 90's and serves as a tendon transfer medially of the Achilles tendon that improve the mechanical effect and rotational equilibrium of the subtalar joint axis and the extrinsic muscle insertions on the medial side of this axis. (6) A personal preference for over 20 years in adults has been to use the medial calcaneal displacement osteotomy and literature now indeed confirms that the medial calcaneal osteotomy decreases strain on the spring ligament and provides a relative shortening of the spring ligament complex that affords a protective effect whereas the Evans osteotomy does not. (7,8) No statistical differences in subtalar joint pressures have been shown in cadaveric models between the medial displacement or the Z osteotomy of the calcaneus and the medial displacement is less technically demanding with a lower risk to neurovascular structures potential hence the continued preference for the medial calcaneal displacement osteotomy.(9)

The Medial Column

What to do with the medial column laxity and insufficiency in the surgical management of flatfeet is a critical decision in obtaining reliable and lasting results and satisfied patients. As alluded to earlier, a rigidly plantar flexed first ray has the ability to impact the rest of the midfoot and hindfoot mechanics. The options include soft tissue reefing procedures such as spring ligament repair, tibialis tendosuspension procedures such as the Cobb or Youngs versus osseous procedures including the Lapidus, naviculocunieform fusion or the cotton osteotomy. One must include as well the resections of accessory naviculars and modifications of the kidner procedure. We learned in the 90's that the youngs tendonsuspension, which was was Dr. E. Dalton McGlamry's preferred medial column procedure for what was termed the "weakfoot stabilization", did a very reasonable job of alleviating medial arch symptoms but did not produce a visually nor radiographically more appreciable arch. Attention therefore shifted to osseous procedures via the extra articular Cotton opening wedge osteotomy of the medial cuneiform or the Lapidus or naviculocunieform fusions. An orderly approach to rationale for selecting one procedure versus the other is to first consider if there is 1st tarsometatarsal degenerative changes, instability or hallux valgus – if so perform the Lapidus, consider second if there is navicular cuneiform degenerative changes or faulting – if so perform the naviculocunieform fusion, and finally consider if there is supinatus without joint faulting on a lateral weight bearing x-ray and if so perform the cotton osteotomy.(10)

Although a solid algorithm to follow the navicular cuneiform fusion in this author's experience offers the most definitive stability with the least chance of an incomplete correction or need for a revisional surgery in the future. It is particularly indicated in higher BMI adolescents as trends toward further weight gain and obesity potentially compromise the long term results of the alternative medial column procedures. Hanson's concept of essential joints versus non-essential joints categorizes joints into those with rounder joint surfaces and larger ranges of motion necessary for forward ambulation as contrasted to those with shorter squarer surfaces and more necessary for stability. The surgical application of this concept may be summarized as seeking to gain the most stability through non-essential joints while preserving maximum mobility through the essential joints. Examples of the

essential foot joints are the talonavicular, metatarsophalangeal and cuboid – 4th 5th metatarsal while the most frequently considered non-essential joints are the naviculocunieform, tarsometatarsal and intercunieform joints.

The naviculocunieform joint is the weak link of the foot and any instability here affects the kinematics of the three major tendons that insert just proximal and just distal to it; the tibialis posterior, the tibialis anterior and the peroneus longus tendons. Spring ligament or plantar calcanealnaviculcarcunieform ligament is also subjected to more strain when there is instability of the medial column thru the naviculocunieform joint. Historically fusion of this joint was associated with an unacceptably high complication rate however this really seems to have been due to an inadequate appreciation of the anatomy of the joint and inadequate surgical technique.(11) The key technical pearl for successful fusion and recreation of the medial arch is too activate the windlass mechanism prior to joint surface preparation thereby avoiding excessive boney resection and capturing the joint fusion in the position of desired correction. (figure 7) It is also unnecessary to prepare nor fuse the lateral facet and attempts to do so increase the risk of nonunion due to bone loss. It has consistently been observed that all clinical and radiographic parameters of the talonavicular- 1st ray alignment both on AP and lateral views improve post navicular cuneiform fusion in combination with hindfoot stabilization of either an extraosseous subtalar implant or medial calcaneal displacement osteotomy in spite of not touching the talus at all. This is further evidence of the ability surgically to simply derotate the foot plate back around and underneath the talar head and neck. The talus remains only passively involved in the actual flatfoot deformity. (figures 8, 9, 10)

The modifications of the youngs and kidner procedures are reserved for those lower BMI adolescent patients that have

Figure 7. The resection of the navicularcunieform joint is initiated while the windlass mechanism is activated by extension of the great toe thereby ensuring the closepacked conFiguretion of the medial arch. It is an error to resect the joint first and then seek the optimal position of the joint later.

accessory naviculars and the absence of navicular cuneiform faulting. When combined with arthroeresis or when necessary a calcaneal osteotomy the results are equally powerful. The suprastructural deformities and rotations may show marked improvement as well which can favorably influence the documented affectation of the lower limb power line and lower extremity alignment and patellar subluxations in adolescents. (12) (figure 11)

The Adult

The surgical management of adult acquired flatfeet follows similar procedural guidelines as adolescent flatfoot with the additional considerations of attention to the spring ligament and single or multiple joint fusions in more rigid cases. The role of both spring ligament failure as a primary defect in the development of adult acquired posterior tibial tendon insufficiency is now well understood as well as is the benefit of inspection and repair in combination with other reconstructive procedures. This recognition has improved the results of stage 2 adult acquired flatfoot repair in combination with traditional approaches of flexor digitorum longus transfer combnined with medial calcaneal displacement osteotomies. (13,14) When arthritic changes and/or rigid flatfoot deformities are present surgical decision making revolves around joint fusions typically of an isolated talonavicular or subtalar joint fusion. More recently over the last 10 years the trend toward medial double fusions of the 2 joints together while sparing the calcaneal cuboid joint has been popularized. Isolated talonavicular joint fusions are most reliably performed via a double incision approach to ensure access to the lateral one third of the joint. When non-unions of isolated talonavicular fusions occur it seems the internal fixation has always been predominantly placed medially due to a single medial incision approach. This may be rectified by use of a two incisional approach or alternatively making a single incision but instead of between the tibialis anterior and posterior tibial tendons more dorsally between the tibialis anterior tendon and the extensor halluces longus tendon. The internal fixation construct needs to be spread equally across the whole medial to lateral width of the joint. It is clearly understood and studied that isolated talonavicular joint fusions block the majority of the remaining hindfoot motions more than any other isolated joint fusion. However, it also seems to provoke more lateral column pain along the calcaneocuboid joint due to compensations and therefore this authors preference is to do a double fusion and preferably a subtalar and naviculocunieform fusion. Caution is advised that isolated subtalar joint fusions may still require a medial column procedures such as a cotton to derotate the midfoot and achieve a stable plantar flexed first ray. (Figure 12) The debate as to the true long-term benefits or failure rates of double fusions versus traditional triple arthrodesis is still ongoing with a recent study concluding that double arthrodesis had greater rates

Figure 8. Postoperative view left foot after arthroereisis plus naviculocunieform fusion and preoperative view of right foot. Note the excellent clinical appearance of the arch and overall foot alignment.

Figure 9. Intraoperative flouro shot of patient in figure 8.

of nonunion or incomplete union with significantly inferior subjective outcome scores compared with triple arthrodesis. (15,16,17). As noted previously, a very attractive alternative that this author has favored for years is to combine a subtalar and navicular cuneiform joint fusion instead of performing a triple arthrodesis thereby sparing the midtarsal joint for improved midfoot mechanics and less risk of adjacent joint arthritis.(18) (figure 13)

Additional Points

Congenital tarsal coalitions are an additional cause of rigid flatfeet in pediatric or adolescent patients that most frequently affect the talocalcaneal joint. These conditions have received a burgeoning interest in recent years as a more thorough understanding of their true morphology has evolved. Excision of the newly described posteromedial subtalar joint coalition have had patient- based clinical outcomes that were significantly better than those patients with a standard middle facet coalition. Innovative work has recently been published detailing the intraoperative use of three dimensional navigation for coalition resection as well as operative excision followed by silicone gel sheeting interposition that showed promising results at an average of 40 months postoperative follow-up. (19, 20, 21,22) Current practice guidelines and this

Figure 10. Pre and postoperative xrays both AP and lateral views of a medial calcaneal displacement osteotomy combined with a naviculocunieform fusion. Note on the postop (B) AP how the talar head is now covered and the calcaneocuboid angle is realigned. Note on the lateral view (A) how the talar to first metatarsal angle has improved as well as the cyma line and there is no longer the superposition of the navicular over the cuboid.

Figure 11. Note the clinical correction after the performance of an excision of an accessory navicular plus kidner procedure plus arthroereisis in the sinus tarsi. The improved structural alignment is noted even at the hip and posterior iliac crest level with the increased pelvic tilt toward the nonoperated left side.

Figure 12. Same patient as in figure 6. Due to iatrogenic complication bilaterally of inaccurate placement of a sinus tarsi implant this patient required conversion to a subtalar joint fusion 7 years later as well as a cotton osteotomy to derotate the medial column.

Figure 13. Combination of a subtalar joint fusion and naviculocunieform fusion that is a very effective way to stabilize the hindfoot and medial column yet not sacrifice the midtarsal joint. I call it colloquially a "poor man's triple arthrodesis" yet is not as debilitating.

author's current preferences are to always consider coalition resection if no significant degenerative joint changes are present in the affected joints while simultaneously correcting the associated flatfoot deformity applying the aforementioned principles. This typically involves a calcaneal osteotomy for correction of the associated lateral column compressive forces. (figure 14)

The forming forces of equinus and the posterior muscle group must be carefully considered in all patients suffering from symptomatic flatfeet. Very frequently, yet not always, a gastrocnemius release or Achilles tendon lengthening will be required but its necessity must be carefully checked in every case. Note that in figure 4 no posterior muscle lengthening was required in spite of the severe pronation and collapse hindfoot and midfoot.

Lastly, the order of procedural selection in flatfoot surgery requires careful consideration as well. It seems most prudent in pediatric and adolescent flatfoot surgery to do the posterior muscle lengthening surgery first as once done it may affect the further procedural selection or corrections necessary. In adult flatfoot surgical repair it is most prudent to do the lengthening last to minimize the risk of overlengthening as the ability for adults to rehabilitate their gastrocsoleal complex is more challenging. Finally, when combining lateral column procedures with medial column procedures it is

Figure 14. Preop CT scan 3D of a middle facet partially ossified coalition. Postoperative lateral xrays of the evans calcaneal osteotomy required to correct the associated flatfoot that was performed at the same time as the excision of the partially ossified tarsal coalition.

preferable to gain the osseous correction laterally first so that any resultant laxity of the medial soft tissue structures may be maximally tensioned during the stabilization of the medial column as the subsequently performed procedures.

CONCLUSSIONS

Flatfoot surgery remains a daunting challenge for surgeons and patients alike once symptoms have progressed to a point of diminished quality of life and pain intolerance. Only with a seasoned approach to clinical examination, consistent review of evolving literature, maintenance of surgical skills via continuing educational courses and balanced empathic and in depth discussions with patients regarding their desired expectations can consistent results be obtained. No single surgeon should stay married to one favorite surgical approach. Each foot is unique and although generalizations may be made regarding treatment guidelines and procedural selection each patient remains an N of 1. (23) Nothing epitomizes the mix of the art and science of foot surgery better than the rewarding pursuit of improving patients' lives thru carefully selected and performed surgical reconstructions of recalcitrant painful flatfeet when indicated.

CONFLICTS OF INTERESTS
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