The Evans Calcaneal Osteotomy for Correction of Flexible Flatfoot Syndrome

The Evans calcaneal osteotomy is used to correct the flexible flatfoot deformity. The procedure restores functional integrity to the medial longitudinal arch and reestablishes the locking mechanism of the midtarsal joint complex. A preliminary analysis of 36 cases (50 feet) performed at Atlanta Hospital and Medical Center during the past 3 years has yielded favorable results.

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Collapsing pes planovalgus deformity has been addressed by various surgical means in an attempt to discover the operative solution for its correction. Unfortunately, many long-term results have been unsuccessful because surgeons have failed to recognize the multiplicity of factors contributing to the deformity. Recent evidence revealing that the dynamically loaded arch is maintained by osseous and ligamentous support, rather than muscular contraction, has altered our approach to flatfoot evaluation (1, 2). Traditional concepts of medial column arthrodesis (3-5) and medial column teno-suspension (6, 7) have been superseded in favor of more sophisticated osseous reconstructive techniques (8-12).

One such technique, proposed by Dillwyn Evans in 1975, is aimed at both equalizing the lengths of the medial and lateral columns of the foot and indirectly shifting the navicular medially about the head of the talus (13) (Fig. 1). The procedure involves an osteotomy of the anterior calcaneal process with distal advancement of the segment by utilizing a bone graft (Fig. 2). The technique has been modified by Ganley (J. Ganley, Hershey Surgical Seminar, Pennsylvania Podiatry Society, November 1979), Langford and McGlamry, (J. Langford, E. D. McGlamry, Doctors Hospital Surgical Seminar, Atlanta, 1982) and adjusted by surgeons at Atlanta Hospital and Medical Center.

In this presentation the biomechanical effects of midtarsal pathology, application of the Evans procedure, indications, contraindications, technique, and complications of the Evans flatfoot correction are reviewed. The experiences of surgeons with the surgery are discussed, based on 36 cases (50 feet) during the past 3 years. The Evans procedure is recommended when uncontrollable hypermobile flatfoot syndrome is complicated by instability of the midtarsal complex.

Midtarsal Pathology and the Evans Restoration

Five major systems have been identified that have dramatic effects on the integrity of the longitudinal arch: 1) the midtarsal locking mechanism, 2) compressive joint tracking, 3) the windlass mechanism, 4) the plantar aponeurotic fascial bands, and 5) medial column structural deficits (4, 5, 14-17).

These systems act as a mechanical synctium to coordinate the closed kinetic chain activity of the foot in maintaining the longitudinal arch during weight-bearing.

1. The Midtarsal Locking Mechanism. A stable midtarsal complex is pivotal in supporting the mechanical expression of the above systems. All systems require the stability of the forefoot for proper function, as controlled by the midtarsal joint. The midtarsal joints translate the dynamic forces of both the leg and ground to the longitudinal arch and the forefoot. Both intrinsic and extrinsic pathology affecting this complex will promote its dysfunction and subsequently reduce the efficiency of the remaining four systems. Pathology in the midtarsal complex may develop from stresses induced by either compensation for subtalar pronation or by anatomic malalignment of the midtarsal joint structures. Flatfoot genesis, secondary to midtarsal pathology, can be classified, in this regard, as either acquired or congenital. This midtarsal breakdown will create a characteristic flatfoot appearance: a) medial column

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0449/2544/84/0234-0291$02.00/0
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locking of the midtarsal complex by subtalar pronation will promote increasing ranges of both abduction and dorsiflexion of the forefoot about this axis. An abducted forefoot position will develop at the midtarsal level, from compensatory changes.

Concurrently, the talonavicular joint is adducted medially with subtalar pronation to enhance further midtarsal unlocking. This compensated position malaligns the talus with the navicular, hindering weight-bearing joint mechanics.

1B. Congenital Midtarsal Flatfoot Syndrome. Elftman (14) determined that for proper medial arch integrity the OMTJ must fall in a direction that passes just anteroplantar to the sustentaculum tali and medioplantar to the talar head. Root et al. (21) considered that some flatfoot types present with an OMTJ axis that is more vertical from the transverse plane than the average 52 degrees as reported by Manter (18) and Hicks (20). These axial deviations allow abnormal ranges of transverse plane motion of the forefoot to dominate at the midtarsal level. Dissection studies on congenital vertical talus cadaver feet support this congenital view of vector malposition. Both lateral obliquity of the calcaneocuboid joint and lateral deviation of the talar cartilaginous head were associated with a laterally abducted forefoot position within these specimens (27).

Chronic subluxation of the midtarsal complex from these two instances may lead to marked distortion in the remaining four systems and to a “fixed” flatfoot deformity from adaptive changes in the midtarsal enchondral bone and joint structures (28, 29). The locking mechanism must be restored by the Evans procedure before both arch collapse and structural deficits in the remaining systems can be reversed. The major contribution of the Evans procedure is to adduct the forefoot by either lateral column elongation or wedging, reversing the abducted forefoot position and promoting a more effective axial position of the OMTJ for the locking mechanism.

2. Compressive Axial Joint Tracking. Compression across the joint surfaces within the midtarsal complex is lost as it subluxes. The abnormal dorsiflexion of the metatarsals that ensues in flatfoot pathology (30) does not sustain the retrograde force of ground forces, which is needed for joint compression in the midtarsal area. Articular surfaces lose their ability to track within the confines of the shape of their articular cartilage (28, 31). Aberrant motion may occur.

Mann (15) described that stability of the talonavicular joint was a function of the keystone phenomenon. The dorsally wider, condylar, talar head wedges into the smaller, cup-shaped navicular during propulsion to lock the articular surfaces into a proper axial track for effective weight transfer.
Gamble and Yale (32) showed radiographically that the navicular subluxes laterally with hindfoot syndromes in flatfeet. This maldirected position reduces proper joint compression and may alter both joint function and cartilaginous shape (33, 34) of the talonavicular complex. The efficiency of the keystone principle falters. The Evans procedure reverses this tendency by: a) adducting the forefoot and navicular medi ally onto the talar head to reestablish the talonavicular alignment and the keystone effect, b) promoting joint alignment and axial compression, and c) reducing navicular subluxation by reapproxi mating the levels of the calcaneocuboid and talonavicular joints by lateral column elongation and by closing the talocalcaneal gap. Extensive talar head deviation may require an adjunctive talar wedge osteotomy to realign the articular cartilage. This adjunctive procedure is presently under investigation.

3 and 4. The Windlass Mechanism and Plantar Aponeurosis. At propulsion, calcaneal inclination is maintained by the tension band pull of the plantar fascia via the windlass mechanism (16). Rose (17) and Jones (35) determined that stable plantarflexion of the metatarsals is necessary to resist the retrograde force of the windlass effect. Tension banding support of the arch and retrograde buttressing of the calcaneus at the calcaneocuboid joint is accomplished. Flatfoot syndromes balanced around an unstable midtarsal complex chronically dorsiflex at the metatarsals as the transverse arch collapses with metatarsal base instability. As the plantar aponeurosis displaces laterally with the abducted forefoot, its position under the medial arch is lost, reducing its ability to support the arch by tension banding (28). The calcaneus is no longer restrained from collapsing at this point, and it develops increasing ranges of calcaneal eversion, adduction, and plantarflexion. A rockerbottom tendency develops. At he e1 off, the hindfoot adducts at the midtarsal level, giving the illusion of an abducted forefoot position. Hindfoot adduction causes medial displacement of the ankle-leg axis (30).

The Evans procedure reestablishes the windlass mechanism by: a) promoting stability of the transverse arch and the plantarflexed metatarsal position with a functional locking mechanism, b) promoting proper alignment of the plantar aponeurosis by adducting the forefoot into rectus position under the arch, c) promoting tension band buttressing of the calcaneal inclination with an efficient plantar aponeurotis fascial truss, and d) promoting first ray stability by improving the vectorial pull of the peroneus longus muscle through stabilization of the metatarsal bases and cuboid fulcrum.

5. Medial Column Structural Deficits. Gamble and Yale (32) popularized the view that medial column deficits were secondary sequelae to flatfoot syndromes with hindfoot dysfunction and that the naviculocuneiform sag was the most predominant. Hoke (4) felt that the naviculocuneiform sag was caused by retention of the abducted gait of the child when he first began to walk. Seymour (36) pointed out that it was unlikely that only the naviculocuneiform fault was solely responsible for flattening of the medial arch and that stabilization of only one segment of the complex cannot be expected to prevent collapse of the entire arch. Both Jack (5) and Moeller (F. A. Moeller, Northlake Surgical Seminary, Chicago, Illinois, 1972) felt that if the extent of compensation had progressed to cause a talonavicular sag then a single naviculocuneiform fusion would be insufficient to restore the medial arch. These authors realized that a naviculocuneiform fault was only a singular deficit appearing among various sequelae of a larger problem. They failed to recognize the association between midtarsal instability and flatfoot syndromes.

Medial column faults develop with advancing medial column instability as the longitudinal mid-tarsal axis (LMTJ) is carried medially with subtalar pronation to enhance midtarsal unlocking. The resulting loss of keystone stability of the talonavicular joint reduces effective weight transfer into the medial column. The talonavicular joint is initially guarded from subluxation by the strength of the calcaneonavicular (spring) ligament and the tibialis posterior tendon. Pronatory stress is transferred to the next joint in line with the progression of weight flow, the naviculocuneiform joint.

At this level, distally advancing weight forces progressing from the talonavicular joint meet head on with stresses from retrograde tension, banding travel proximally up the first ray, as initiated by the windlass mechanism, in the later stages of the gait cycle. The combined forces at this point are able to overcome the weaker pericapsular ligamentous structures of the naviculocuneiform joint. The naviculocuneiform joint buckles into a plantarward collapse, creating a fault or sag. Chronic midtarsal subluxation eventually deteri rates the strength of both the calcaneonavicular ligament and the tibialis posterior tendon. A talonavicular fault may progressively develop in end stages.

Humphrey (37) noted from dissection studies on adult flatfeet that degenerative changes occurred in the calcaneonavicular ligament and secondary ostearthritic changes occurred in the calcaneocuboid joint, concurrently. These findings are consistent with chronic midtarsal subluxation.

The combined presence of a naviculocuneiform and talonavicular fault indicates a poor prognosis for a successful singular medial column fusion. The discouraging review of long-term failure for single-column fusion procedures (36, 38) indicates the necessity for addressing the larger etiologic problems of the unlocked
Clinical Examination of the Midtarsal Complex

Non-weight-bearing examination of the midtarsal mechanism is accomplished by using the method of Root and his associates (39). The subtalar joint is held in neutral position while the midtarsal joint is placed throughout its range of motion. Normally, the ratio of dorsiflexion to abduction is two to one. With a hypomobile midtarsal complex, wider ranges of transverse plane abduction will predominate. The second toe reference point can be manually abducted past the longitudinal bisection of the tibia, laterally.

Weight-bearing examination is more indicative of pathology when the joint surfaces of the midtarsal complex are placed under compressive retrograde stress. An incompetent locking mechanism will fail to withstand weight-bearing stress. In stance, the patient will display high degrees of forefoot to rearfoot abducted position. The lateral border will appear concave with the apex centering at the calcaneocuboid joint. Gait analysis will expose an unsteady forefoot fulcrum for propulsion. The foot will appear to wobble from side to side through late stance. Excessive rearfoot adduction will shift the mechanical axis of the leg medially and promote greater bulging of the talar head than would be seen with normal subtalar pronation.

After gross examination is completed, specific tests are applied to evaluate critically the competency of the locking mechanism. All tests are performed while weightbearing to ascertain the influence of joint compression and axial tracking. All extrinsic factors from gross foot types (e.g., forefoot varus, equinus) are negated with wedges or lifts to remove any dynamic stress causing compensatory pronation in the midtarsal complex (23).

The Hallux Push-Up Test. The hallux push-up test (5), or the Hubsher maneuver (40), is used to invoke the windlass mechanism and direct retrograde force through the medial column as the patient stands in the relaxed calcaneal stance position. Tension placed on the plantar fascia causes the heel to invert and the arch to rise under normal conditions (16). With an incompetent longitudinal arch, there will be either no change in arch height or the foot will roll medially with calcaneal eversion (5). Because medial column deficits can, in themselves, initiate valgus collapse of the arch, they must be ruled out before attributing the collapse fully to midtarsal incompetency. Windlass failure is otherwise attributed to midtarsal pathology.

The Arch Suspension Test. The arch suspension test accounts for the ability of muscle groups to initiate supinatory motion of the forefoot about the oblique midtarsal axis. The patient is ordered to raise his arches and bear weight on the lateral border of the foot by contracting the tibialis posterior muscle. The tibialis posterior muscle is a strong supinator of the OMTJ. Normally, the arch should rise as the midtarsal complex locks with supination. Inability to raise the arch suggests either pathology with the tibialis posterior or a defect in the midtarsal locking mechanism.

The Leg Rotation Test. The leg rotation test accounts for pure bone to bone translation of forces from the subtalar to the midtarsal complex. The test is performed by having the examiner kneel next to the patient, who stands on one leg only. The examiner then grasps the weight-bearing tibia with both hands and rotates the leg internally and externally with alternating movements. If the midtarsal joint is competent, the stress transferred from the externally rotating leg will supinate the subtalar joint, lock the midtarsal joint, and raise the longitudinal arch. If the midtarsal joint is subluxed, the arch will remain in a collapsed position, indicating osseous malfunction between the subtalar and midtarsal systems.

Radiographic Examination of the Midtarsal Complex

Gross radiographic signs and angular measurements are correlated to determine the extent of midtarsal pathology. These radiographic indications are vital in determining the exact variation of the Evans procedure (to be discussed) to implement for midtarsal locking restoration. All radiographs are taken in the angle and base of gait. The five major signs are: 1) the cyma line, 2) the talocalcaneal gap, 3) the forefoot abductus breach, 4) navicular lateral subluxation, and 5) the calcaneal inclination. These signs are correlated with their respective angles: 1) the transverse talocalcaneal angle, 2) the talar deviation angle, 3) the calcaneocuboid abductus angle, 4) the talonavicular angle, and 5) the calcaneal inclination angle.

1. Cyma Line Breaching. The cyma line is a major indicator of midtarsal position (Figs. 3 and 4). The farther forward the talar head separates distally from the level of the calcaneocuboid joint, the greater is the degree of midtarsal subluxation implicated. Normally the talonavicular and calcaneocuboid should be approximately level on an anteroposterior view. The transverse talocalcaneal angle best quantifies this relationship by measuring the angular deviation of this breach (Fig. 4). The angle is defined as the intersection of the lateral aspect of the calcaneocuboid joint between a line extending from the most distal aspect of the talar head and a line paralleling the calcaneocuboid joint.
Normal ranges have been reported as 4 to 8 degrees (32). In a review of cases at our institution, an average range of 15 ± 3 degrees was found. Certain, deceptively lower angular values were attributed to artifactual radiographic changes in talar position with extensive midtarsal subluxation. In these instances, excessive plantarflexion and medial rotation of the talus will misleadingly appear to shorten the displacement of the talar head from the calcaneocuboid level. This was verified by noting the degree of talar plantarflexion on lateral views (Fig. 5).

2. Talocalcaneal Gapping. The presence of a gap between the talus and calcaneus in anteroposterior views depicts the deviation occurring with midtarsal subluxation and subtalar pronation (Fig. 3). The talar deviation angle measures the degree to which the talus migrates medially away from the calcaneus. The angle is defined as the intersection of the longitudinal bisection of the talar head with the longitudinal rearfoot axis (Fig. 4). Normal ranges reported are 10 to 20 degrees (32). In a review of our cases, an average range of 25 ± 7 degrees was found. Low to normal talar deviation values, in the presence of marked midtarsal transverse plane hypermobility, were attributed to high verticality of the oblique midtarsal axis position. At times, the rearfoot appeared in a more rectus attitude, even with a wide lateral forefoot abduction.

3. Forefoot Abductus Breaching. A significant indicator of midtarsal position is the angle formed by the forefoot with the rearfoot at the calcaneocuboid lateral border, the calcaneocuboid abductus angle (41) (Fig. 3). Extreme transverse plane hypermobility in the midtarsal complex will allow the rearfoot to adduct away from the forefoot giving the radiographic illusion of an abducted forefoot position and a concavity to the lateral border of the foot (Fig. 4). The relative position of the lateral cuboid and calcaneal borders should approach parallel alignment (42) with acceptable deviations ranging between 2 and 5 degrees (Surgical Lectures, Pennsylvania College of Podiatric Medicine, 1982). Marked abduction at this level signifies midtarsal subluxation. In our study, the average abductus angle was 23 ± 6 degrees. This measurement is considered to be a prime indicator for the Evans osteotomy procedure.

4. Navicular Subluxation. Lateral navicular subluxation occurs as the talus adducts away from the calcaneus. There exists a functional synergism between the presence of both cyma line breaching and talocalcaneal gapping. Notable navicular subluxation, laterally, progressively increases in view of the combined presence of both signs. Morphologic adaptation occurs in the navicular in response to the abnormally displaced compression forces across the talonavicular joint. The navicular alters into a wedge-shaped configuration (Fig. 3). The talonavicular angle is reputed to be an indicator
of this positional distortion occurring with midtarsal pathology (41). This angle is defined as the intersection between the bisection of the navicular body and the talar head (41). No normal values have been established for this angle for comparative study. Both the talonavicular angle and the calcaneocuboid abductus angle together are reputed to be strong indicators of midtarsal position. Progressive navicular subluxation indicates a high tendency in midtarsal hypermobile subluxation.

5. Calcaneal Inclination. The onset of calcaneal planatarflexion heralds the end-stage breakdown of midtarsal stability, with development of rockerbottom tendencies (Fig. 5). The calcaneal inclination angle is a direct measurement of this position (Fig. 5). Normal ranges reported are in the 20- to 30-degree range (43). In our review, an average inclination of $13^\circ \pm 2^\circ$ was noted.

A succession of secondary changes in other osseous structures may develop as sequelae to midtarsal pathology. These changes are medial column faults, talarplosis, first ray elevatus, calcaneocuboid breaching, and gapping between the first and second metatarsal bases (Fig. 5).

The final radiographic evaluation entails comparison of anteroposterior and lateral views taken in both the relaxed and neutral calcaneal stance positions. The overall degree of compensatory changes occurring in the relaxed position can be qualified against the standard neutral position in this manner.

**General Indications for the Evans Procedure**

The following criteria are intended as general guidelines for performing the Evans calcaneal osteotomy for flatfoot correction: 1) flexible pes valgo planus with an abducted lateral forefoot position, 2) clinical subluxation or instability of the midtarsal joint complex with high ranges of transverse plane hypermobility of either acquired or congenital varieties, 3) radiographic evidence of midtarsal unlocking with a prominent abducted lateral border, and 4) medial deviation of the ankle-leg axis in stance.

Additionally, the preceding criteria are defined in terms of the extent of the midtarsal breakdown and its sequelae. The extent of breakdown will determine which of two possible variations in surgical technique to employ.

**Variations in the Procedure**

The primary aim of preoperative evaluation is to determine the extent of midtarsal breakdown. The secondary aim is to determine which of the two variations in technique is best to restore the locking potential. The variations described below should be considered:

- **Total Advancement of the Anterior Calcaneus.** A T-shaped bone graft is used for totally advancing the anterocalcaneal segment to equalize the lengths of the medial and lateral columns and to reapproximate the levels of the talonavicular and calcaneocuboid joint to parity (Fig. 6). Significant distal cyma line breach and talocalcaneal gapping are the major indicators for this variation when the flatfoot syndrome fulfills the general guidelines as presented. These patients tend to fall more into the acquired categories, showing higher ranges of midtarsal pathology because of pronatory compensation.

- **Forward Wedging of the Anterior Calcaneus Lateral Border.** A V-shaped bone graft is utilized to wedge open the lateral aspect of the anterior calcaneus (Fig. 7). Indications for this variation are limited to lesser pathologic degrees of midtarsal instability, when general criteria are fulfilled. Wedging should be performed when the abducted lateral forefoot border is the most significant radiographic sign and cyma line breaching is not excessive. Younger patients are generally chosen for lateral wedge grafting to reduce the risk of arthritic changes from joint jamming. The remodeling potential of joint structures in young patients reduces this risk. These patients tend to fall into the congenital category and the beginning stages of the acquired category of midtarsal syndromes.

Phillips (44), in his review, found no adverse consequences of the Evans procedure attributable to age in a...
7- to 20-year retrospective study of original Evans patients ranging in age from 9 to 42 years. Despite this data we reserve the lateral wedging technique for younger patients.

Contraindications

As in most cases of flexible flatfoot, the major contraindication to non-arthrodesing procedures is a rigid pes plano valgus deformity (13, 45–47). Conditions of ligamentous laxity (48), osseous equinus (49), and certain neurologic conditions (50) are also contraindications. Additionally, the surgeon should recognize that since the midtarsal complex is triplanar, elongation of the lateral column in the presence of a significant congenital metatarsus adductus or varus deformity may accentuate the adducto-varus position of the forefoot to pathologic proportions. Under these circumstances either a modified Berman-Gartland metatarsal base osteotomy (51) or a plantarflexory naviculocuneiform arthrodesis (52) procedure may be necessary. These adjunctive procedures are included in carefully selected cases.

Adjunctive Surgical Procedures

In addition to the Evans procedure we have combined other adjunctive procedures to correct secondary structural deficits of midtarsal pathology: 1) modified naviculocuneiform arthrodesis (4, 52), 2) modified Young teno-suspension (6, 7), 3) gastrocnemius recession (53), 4) Silver opening calcaneal osteotomy (12), and 5) Bermann-Gartland metatarsal base osteotomy (51).

These defects, if uncorrected, may defeat the ability of the restored midtarsal locking mechanism to transfer weight onto a stable framework.

Bone Graft Preparation

Homogenous cortical bone grafts have been utilized with good success at our institution to date. Cortical grafts are secured from prepared cadaver specimens by the University of Miami, School of Medicine, Tissue Bank. The graft is packaged under sterile conditions in a vacuum-sealed bottle. The homogenous graft is reconstituted with saline before surgery and shaped perioperatively (54). Two shapes have been utilized—a T-shaped graft and a V-shaped graft. The T-shaped graft (J. Langford and E. D. McGlamry, Doctors Hospital Surgical Seminars, 1982), when implanted into the calcaneus, is designed to prevent either dorsal or plantar dislocation of the anterior calcaneal segment when the calcaneal osteotomy must be carried through the medial cortex for forward advancement of the total anterior calcaneal segment (Fig. 8). The V-shaped graft is fashioned as a triangular wedge with a gradual taper. When impacted into the calcaneal osteotomy site, the V-shaped graft will distract forward only the lateral aspect of the anterior calcaneus, the calcaneocuboid joint, and the lateral column (Fig. 8).

Both graft types are fenestrated to promote both vascular ingrowth from the host into the graft and creeping substitution of the graft bone by host osteoprogenitor cells (55, 56). Creeping substitution defines the dynamic process of migratory invasion of host osteoprogenitor cells into the graft along the surgically created channels for purposes of incorporation and cellular replacement by host tissue. The fenestrated graft acts both as a spacer to maintain the osteotomy edges pried open and a bridging latticework for migration of host cells to fill in the void. The donor graft is gradually incorporated and resorbed by host cells (Figs. 9 and 10). Total resorption may occur in from 1 to 2 years.

Surgical Technique

Attention is directed to the lateral aspect of the calcaneocuboid joint where an oblique, 4.0-cm. skin incision is made. The incision extends from the superior-distal aspect of the joint and terminates in a plantar-proximal direction 2.5 cm. from the joint. The incision is deepened, carefully isolating and retracting the sural nerve and peroneal tendon sheath. The exten-
the osteotomy site. Tight impaction is sufficient to hold the graft in place.

Total elongation of the anterior calcaneus requires that the osteotomy be carried through the medial cortex. Slots are created on opposite sides of the osteotomy to accept the wings of the T-graft. The T-graft is then impacted into the site.

In both variations, the osteotomy site is distracted until midtarsal transverse plane hypermobility is reduced with manual examination as the forefoot is adducted into a more rectus alignment. Subtalar motion is evaluated to ensure that the graft has not lodged superiorly in the joint. Protruding edges of the graft are smoothed to contour the lateral calcaneal border. The wound site is copiously irrigated. Intraoperative x-rays are taken to assess graft position. Deep and subcutaneous tissue layers are closed with absorbable sutures. Skin edges are coapted closed with nonabsorbable suture material. Sterile dressings and a below-the-knee cast are applied.

**Postoperative Care**

A short leg cast is applied at the time of surgery. The compliant patient is allowed non-weight-bearing bathroom privileges in 24 hr. and ambulation privileges with crutches 3 days postoperative, non-weight-bearing on the surgical extremity. The patient is discharged after vital signs stabilize.

After 6 weeks, the cast is bivalved and x-ray review of bone-healing is evaluated. Range-of-motion and strengthening exercises are initiated twice a day for 4 more weeks. Strengthening exercises are performed to improve atrophied muscles. The patient’s parent offers passive resistance to the foot as the patient applies an isometric contraction for dorsiflexor, plantarflexor ev- ertor, and invertor muscle groups. When weightbearing is allowed, the patient is put through a series of intoeing walking exercises, actively contracting the tibialis posterior muscle group. In the first series, the patient is instructed to walk on the outside border of the foot, and in the second series the patient is allowed to raise his heels and walk intoeed on the balls of his feet.

At 8 to 12 weeks, all cast immobilization is removed and physical therapy is continued as needed. Orthotic therapy is instituted for up to 2 years to support bone remodeling phases. Recovery is usually uneventful if both surgical technique and postoperative orders are adhered to closely.

**Complications**

Complications following the Evans calcaneal osteotomy can be divided into two types.

1. Surgical complications occur intraoperatively and
may result from errors in surgical technique. They consist of the following: dorsal or plantar dislocation of the anterior calcaneal segment (Fig. 11); impaction of the cortical graft into the subtalar joint (Fig. 12); osteotomy fracture into either the middle calcaneal facet or the calcaneo-cuboid joint; and over-elongation of the lateral column, producing an excessively adducted forefoot.

2. Rehabilitative complications that may occur postoperatively consist of: graft resorption by cancellous bone, resulting in loss of correction; first metatarsal-cuneiform joint jamming, resulting from an overly adducted forefoot; peroneal tendonitis, from the lengthened lateral column; and mild transient limping.

Discussion
Operative success can be viewed in either of two regards. The postoperative anatomic reduction of the severely collapsed pedal skeleton is evaluated against the preoperative neutral calcaneal stance position on x-ray. The degree of postoperative reduction in the compensatory collapsing of the midtarsal joint structures and associated deficits in comparison with the previous preoperative relaxed calcaneal stance position will show how well the foot has been surgically returned to neutral position. The patient is then evaluated for symptomatic relief of preoperative complaints and functional return to physical activity.

Long-term review is needed to evaluate best the successful longevity of the procedure. In 1983, Philips (44) reviewed 20 patients involved in the original Evans flatfoot study of 1959–1974. The follow-up ranged from 7 to 20 years. He determined that 17 of 23 feet showed undoubted improvement with 3 feet demonstrating only fair results. Three failures were attributed to causes unrelated to the surgery. Most importantly, he discerned that significant stiffness did not develop in any joint of the hindfoot as a result of the procedure and that the patient was unlikely to be compromised.

In reviewing current thought in the evaluation of foot pathology, tremendous emphasis has been placed on subtalar joint activity and factors affecting its position. Little emphasis has focused on the importance of the midtarsal complex and the function of its locking mechanism. This has probably resulted from the difficulty in understanding the interplay between the dual axis nature of the complex and its clinical function. From our experience, stability of the foot is guided by this locking mechanism, which becomes the relay point for the translation of forces into the midfoot by the subtalar joint-leg interface and the forefoot-ground interface. Although the subtalar joint is a vital key, opening and closing the lock, the structural lock must also be functionally sound. Without an efficient locking mechanism, the synchrony of interdependent joint mechanics is pathologically altered.

For these reasons, the overall evaluation of the foot requires exacting determination of midtarsal function. If the midtarsal complex can be demonstrated to retain an acceptable level of locking stability with the clinical use of the hallux push-up test, the arch suspension test, and the leg rotation test, then alternative, nonjoint invasive flatfoot procedures (e.g., the Silver calcaneal osteotomy) are implemented rather than the Evans osteotomy. If the flexible flatfoot is reducible with these tests on weightbearing and the child is asymptomatic, then orthotic therapy is warranted until the progressing extent of structural breakdown and symptoms indicate surgery.

In view of both the short- and long-term success of the operation, future operative considerations should include the relative guidelines and criteria as set forth by this study. Further studies are recommended to delineate normal ranges for the talonavicular angle for more definitive radiographic criteria in establishing the extent of midtarsal pathology. Results from this study and others suggest that the Evans procedure is successful in flexible flatfoot correction, when the major etiology can be associated with functional midtarsal pathology (Figs. 13 and 14). Further studies are suggested.

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Long-term review is needed to evaluate best the successful longevity of the procedure. In 1983, Philips (44) reviewed 20 patients involved in the original Evans flatfoot study of 1959–1974. The follow-up ranged from 7 to 20 years. He determined that 17 of 23 feet showed undoubted improvement with 3 feet demonstrating only fair results. Three failures were attributed to causes unrelated to the surgery. Most importantly, he discerned that significant stiffness did not develop in any joint of the hindfoot as a result of the procedure and that the patient was unlikely to be compromised.

In reviewing current thought in the evaluation of foot pathology, tremendous emphasis has been placed on subtalar joint activity and factors affecting its position. Little emphasis has focused on the importance of the midtarsal complex and the function of its locking mechanism. This has probably resulted from the difficulty in understanding the interplay between the dual axis nature of the complex and its clinical function. From our experience, stability of the foot is guided by this locking mechanism, which becomes the relay point for the translation of forces into the midfoot by the subtalar joint-leg interface and the forefoot-ground interface. Although the subtalar joint is a vital key, opening and closing the lock, the structural lock must also be functionally sound. Without an efficient locking mechanism, the synchrony of interdependent joint mechanics is pathologically altered.

For these reasons, the overall evaluation of the foot requires exacting determination of midtarsal function. If the midtarsal complex can be demonstrated to retain an acceptable level of locking stability with the clinical use of the hallux push-up test, the arch suspension test, and the leg rotation test, then alternative, nonjoint invasive flatfoot procedures (e.g., the Silver calcaneal osteotomy) are implemented rather than the Evans osteotomy. If the flexible flatfoot is reducible with these tests on weightbearing and the child is asymptomatic, then orthotic therapy is warranted until the progressing extent of structural breakdown and symptoms indicate surgery.

In view of both the short- and long-term success of the operation, future operative considerations should include the relative guidelines and criteria as set forth by this study. Further studies are recommended to delineate normal ranges for the talonavicular angle for more definitive radiographic criteria in establishing the extent of midtarsal pathology. Results from this study and others suggest that the Evans procedure is successful in flexible flatfoot correction, when the major etiology can be associated with functional midtarsal pathology (Figs. 13 and 14). Further studies are suggested,
investigating the possible use of the Evans procedure on the flexible anterior cavus foot type, which produces a weakfoot-flatfoot condition in breaking down the midtarsal complex.

Acknowledgments

The authors wish to acknowledge the assistance of James Bouchard, D.P.M., Nathan Schwartz, D.P.M., and Spencer Misner, D.P.M., in the preparation of this manuscript.

References


Additional References