END-STAGE FLATFOOT: A Classification to Improve Treatment Selection

Stephen J. Miller, DPM

INTRODUCTION

The flexible flatfoot has a natural progression which is identified by symptoms and deformity. This is the result of a long-term maximally-pronated foot that remains so throughout the stance phase of gait. The symptoms and deformity generally become more advanced with time.

Some flat feet never become symptomatic, however, many become painful at some time during the patient's life. Early symptoms include intrinsic muscle cramps, arch fatigue, heel pain, posterior leg cramps, metatarsalgia, joint pain, and tendonitis. Late symptoms include sinus tarsitis, deep aching arthritic pain, joint swelling and tenderness, chronic tendonitis, and occasional crepitus. The patient is usually unable to find comfortable shoes.

As the foot continues to function maximally pronated, there is a gradual regression to the end-stage flatfoot syndrome. The presenting symptoms and deformity, as well as any degenerative changes, will depend upon the level of compensation, location of stress points, and severity of pathology present. Defining these factors will help lead to accurate and successful treatment.

DEFINITION AND DESCRIPTION

End-stage flatfoot is a painful tarsal enthesopathy/arthropathy which is the result of severe long term pronation of the foot about the subtalar and other midfoot joints. Various additional stages of this natural progression are also evident and identifiable. Although the joints are the points of compensation and stress due to the forces of weight bearing, degenerative changes are not always seen even at the later stages of development. However, pain is evident at these sites, especially within the subtalar joint. Tarsal pain is the common denominator.

Initially the pathology is limited to soft tissues, but with progression of the disorder, joint adaptation and subluxation occurs, leading in many cases to eventual joint destruction.

DIAGNOSIS

Diagnosing the stage of the flatfoot deformity is based upon the sum of the physical findings, including level of compensation, radiographic interpretation, and evaluation of the patient's gait, particularly at midstance. The most common site of pain is the sinus tarsi. It has been fairly well defined in the literature as sinus tarsitis or sinus tarsi syndrome. Other locations of pain include the cuboid joints, both proximally and distally, the subtalar joint medially and/or laterally, the midtarsal joints, the midfoot joints including the naviculocuneiforms, and the tarsometatarsal joints. The location depends on the level of compensation. The exact location can be delineated by careful palpation and manipulation of the joints of the affected foot. Occasionally crepitus can be elicited.

Medial arch pain is also a common finding, most often involving the talonavicular joint at or near the insertion of the tibialis posterior tendon. Posterior tibial tendonitis is the result of abnormal pulling on the posterior tibial tendon through pronation, and can result in a chronic tenosynovitis which may eventually lead to complete tendon dysfunction or rupture. Leg cramps and shin splints are generally less common than joint pain. Usually, these painful anatomical locations remain constant with weight bearing and are fairly resistant to conservative treatment. Pain is usually relieved by rest.

Observing the foot at midstance reveals flattening of the longitudinal arch, accompanied by relative inversion of the forefoot and a valgus position of the heel. Gait is usually apropulsive with varying degrees of abduction. There is a midfoot break following heel-lift, best seen by observing the lateral border of the foot. A flexible flatfoot is usually accompanied by contracture of the gastrocnemius or triceps surae muscles, reflected in a tight achilles tendon. This additional deformity has an enormous influence on the level of compensation and severity of symptoms by restricting dorsiflexion of the foot through the stance phase of gait, particularly during propulsion. It forces compensation at some level and is defined as gastrocnemius or triceps surae equinus. It can only be measured accurately with the foot in a neutral position. The foot remains pronated throughout the total stance phase of gait from heel contact to toe-off.

Weight-bearing radiographs should be taken in the angle and base of gait, one foot at a time. Anteroposterior and lateral views are the minimum exposures to be taken. Depending on the point of stress and plane of compensation, the anteroposterior view may show medial subluxation of the talonavicular joint, anterior break in the cyma line, and a calcaneocuboid abduction angle in excess of 10 degrees. The lateral view may show an increase in the talar declination angle falling well below the first metatarsal bisection, a decrease in the calcaneal inclination angle, an anteriorly displaced cyma line, and the lateral process of the talus will be seen resting on the floor of the sinus tarsi. Points of stress can be identified by observing for subchondral sclerosis, periarticular osteophytes, loss of joint space, and irregularities in the articulations.

PLANAL DOMINANCE

By using the concept of planal dominance developed by Green and Carol, the major plane of compensation can be determined as the flatfoot, being observed, progresses towards its end-stage. There are three planes in which compensation can occur. When the axis of the subtalar joint or midtarsal joint lies close to vertical, the majority of motion and compensation will occur in the transverse plane. When the axis lies closer to the frontal and horizontal planes, then the majority of motion and compensation will be observed in the sagittal plane.

Finally, when the axis of these joints lies closer to the horizontal and sagittal planes, the majority of motion and compensation will be seen in the frontal plane. Understanding planal dominance is especially useful in selecting the corrective surgical procedures that will functionally realign the foot.

The calcaneal axial view can also be quite helpful in determining where the calcaneus is sitting in the stance position, and if there has been adaptation, particularly of the middle facet of the subtalar joint. Also, degenerative changes can be seen in the posterior facet of the same joint complex.

CLASSIFICATION AND STAGES

A compensated flexible flatfoot, as it progresses on towards its end-stage, can be classified by location, and staged by pathology. The purpose of classifying and staging the flexible flatfoot is to provide a reference for which a treatment plan can be applied.

The classification refers to identifying the major joint or joints at which the compensation for the deformity is occurring. This will demonstrate as abnormal findings on x-ray such as subluxation of the midtarsal joint. The apex of deviation at the points of maximal stress are sometimes seen as faults, particularly in the lateral projections. Subtalar joint pronation, as evidenced by closure of the sinus tarsi and resting of the lateral process on the floor of the tarsal canal, and degenerative changes at sites of maximal stress, also define the degree of deformity.

Locations of points of maximal tarsal stress observed in a flexible flatfoot include one of the

following by classification: subtalar joint, midtarsal joint, midfoot joints, and tarsometatarsal joints. In general, the pathology present in the flexible flatfoot, as it progresses towards end-stage, can be divided into three stages.

Stage I

This is the stage of soft tissue pathology in the face of flexible subluxation. The deformity is manually-reducible by applying the Jack test (using the windlass effect by dorsiflexion of the great toe and recreating the arch). During this stage there is usually inflammation, swelling, tendonitis, and muscle dysfunction accompanying the deformity. The peroneus longus muscle may be unable to plantarflex the first ray and therefore is dysfunctional. The posterior tibial tendon is also dysfunctional, as it may be unable to adduct the foot around the midtarsal joint. These findings may occur in a later stage. For example, tendon dysfunction is often seen in Stage II.

Stage II

At this stage the deformity is readily evident as a semi-rigid or rigid configuration. It is difficult to re-create the arch by using the Jack test. When the subtalar joint is evaluated, it tends to "track" and cannot be held in a neutral position. The plane of compensation should be clinically and radiographically evident at this stage. The joints should all be reasonably mobile, although they are most comfortably set and adapted at their end range of motion. (Figures 1A&B, 2A&B)

Figure 1A&B. Lateral (A) and DP (B) radiographs of a Stage II Flatfoot with Class B joint compensation (midtarsal joint).

Figure 1B.

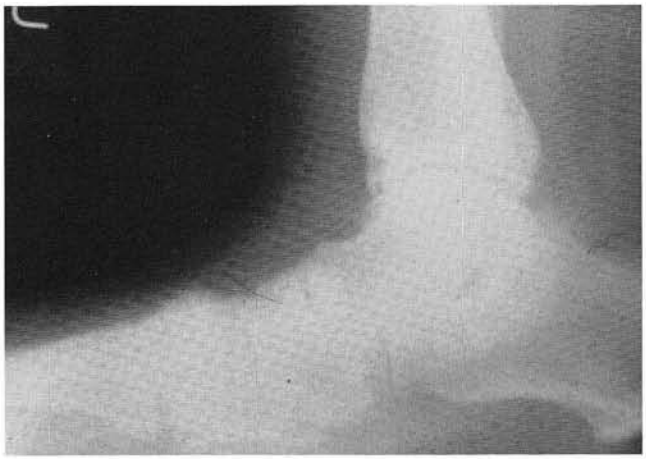

Figure 2A&B. Lateral (A) and DP (B) radiographs of a Stage II flatfoot with class C joint compensation (midfoot joint).

Figure 2B.

Stage III

Stage III is the end-stage of a flexible flatfoot. At this stage the deformity is quite rigid, and joint deformation is seen on radiographs where the maximal compensation and points of stress have occurred. At this stage, some joints may be in Stage III, while other joints are in Stage II. The plane of compensation is established and virtually non-reducible. This stage is usually poorly responsive to conservative measures and requires osseus correction to alleviate symptoms. (Figures 3A, 3B)

Figure 3A&B. Lateral (A) and DP (B) radiographs of a Stage III flatfoot with class D joint compensation (tarsometatarsal joint).

Figure 3B.

By staging the extent of pathology in conjunction with the anatomic classification, the clinician is better able to select combinations of conservative treatments. When this fails using the same classifications and staging methods, appropriate surgical procedures can be selected to functionally realign the foot with the goal of alleviating symptoms, while minimizing the development of compensatory changes in surrounding joints.

The end-stage flatfoot is generally found in Stages II and III of this classification. It may actually be a combination of findings in each stage. For example, the naviculocuneiform joints may demonstrate marked degenerative changes at the point of maximal stress, while the midtarsal joint in the same foot shows a semi-rigid, partially reducible subluxation with pain and tenderness at the talonavicular joint.

CONSERVATIVE TREATMENT

The treatments outlined are directed primarily toward the end-stage flatfoot. The goal of treatment for the end-stage flatfoot is to reduce or eliminate pain while allowing some degree of function. Non-surgical management includes rest, limitation of walking, moist heat, compression, and accommodative shoes to support the deformed foot. Pads and tape strappings provide varying degrees of temporary relief. Rigid orthoses should be avoided in favor of soft orthoses that both accommodate and cushion the non-shock absorbing foot. Holding the foot in a neutral position is impossible.

Joint and inflammatory pain can be treated with non-steroidal anti-inflammatory drugs. Appropriate precautions should be taken relative to the side effects when these drugs are prescribed over long periods of time. Localized corticosteroid injections for specific sites of inflammation and discomfort can provide dramatic although, only temporary relief. Injections into the sinus tarsi are especially effective when inflammation is present at that site. The structure is divided roughly into anterior and posterior compartments by the talocalcaneal ligament. Therefore, the hypodermic needle should be directed anteriorly and medially for the initial deposit, and then posteriorly into the posterior facet of the subtalar joint for the second deposit.

In order to further identify the joint that might be responsible for the greatest amount of discomfort, a diagnostic nerve block of local anesthetic can be used. If immediate and dramatic relief is obtained, then the joint responsible for the majority of symptoms is identified.

SURGICAL MANAGEMENT

There are three approaches to the surgical management of end-stage flatfoot. These include soft tissue procedures, non-joint destructive osseous procedures, and arthrodeses. (Table 1)

Table 1

Guide to Surgical Correction of End-Stage Flexible Flatfoot With Suggested Procedures

POINTS OF COMPENSATION	A. SUBTALAR JOINT	B. MIDTARSAL JOINT	C. MIDFOOT JOINTS	D. TARSOMETATARSAL JOINTS
STAGE I SOFT TISSUE	STA PEG MAR SINUS TARSECTOMY	DESMOPLASTY TNJ MAR EVAN'S PROCEDURE (OCCASIONALLY)	ADVANCE PT TENDON	SHORTEN PL TENDON
STAGE II RIGID/SEMIRIGID	STA PEG MAR ARTHRODESIS STJ GRICE PROCEDURE REVERSE DWYER	MEDIAL COLUMN FUSION EVAN'S PROCEDURE MAR	MEDIAL COLUMN FUSION	MEDIAL COLUMN FUSION
STAGE III DEGENERATIVE	ARTHRODESIS STJ TRIPLE ARTHRODESIS	ARTHRODESIS TNJ TRIPLE ARTHRODESIS	ARTHRODESIS SPECIFIC JOINT(S)	ARTHRODESIS OSTOARTHROTOMY

MAR = Medial Arch Reconstruction NB = Must also take into account the planal dominance

The first soft tissue procedure involves excision of the sinus tarsi plug. This is essentially a synovectomy used to treat painful and unremitting sinus tarsitis. It removes the fatty plug of tissue, including the neurovascular elements from within the sinus tarsi itself. The procedure is relatively simple and it allows for immediate weight bearing.

Another soft tissue approach is a capsulorrhaphy-type procedure, also known as a dermoplasty, which is usually performed on the talonavicular joint. In this procedure, the spring ligament and associated medial capsule of the talonavicular joint are dissected to create a proximally or distally-based flap. A distally-based flap can be sutured into the deltoid ligament while reducing the talonavicular joint. A proximally-based flap can be advanced distally and sutured into the insertion of the tibialis anterior or other structures.

Other procedures that assist in the surgical correction of flexible flatfoot at this stage may include tendon transposition, such as the tibialis anterior through a slot in the navicular to provide a "sling", or advancement of the posterior tibial tendon, or even flexor digitorum longus tendon, along the medial aspect of the foot to reinforce the medial column. Shortening of the peroneus longus tendon can also be considered to augment the medial column repair.

Osseous procedures for the treatment of flexible flatfoot which are non-joint destructive include arthroereisis, Evan's calcaneal osteotomy, reverse Dwyer calcaneal osteotomy, or the Grice extra articular arthrodesis procedure. Less common procedures that may be used include an opening cuboid osteotomy, a closing medial cuneiform osteotomy, and a talar neck osteotomy.

Arthrodesis procedures are commonly used to treat end-stage flatfoot. Usually these are directed at the most degenerated joints, but in order to achieve stability and long term function, additional joints may be fused at the same time. This may include arthrodeses of a single joint such as the subtalar joint, talonavicular joint, or one of the midfoot joints. When several of the midfoot joints have become painfully arthritic, all of the affected joints may be fused. Midfoot fusions rarely disrupt foot function since these joints move little in the first place. Multiple joint fusions might include medial column fusions, tarsal metatarsal joint fusions, or triple arthrodesis. When the ankle joint is severely deformed or degenerated, a pantalar arthrodesis may be indicated.

ADDRESSING EQUINUS

In surgically treating a flexible flatfoot, regardless of the stage, classification, or plane of compensation, attention must be directed to the contracture deformity of the triceps surae complex. The influence of the power of this muscle tendon complex on maintaining a flatfoot deformity cannot be under-estimated. It is the second strongest muscle tendon group in the body. Through lever and fulcrum action, it imparts an enormous force into the foot. As a result, it magnifies the deformity already created by the compensation for the flexible flatfoot.

CONCLUSION

End-stage flatfoot is a clinical syndrome that can be frustratingly painful to patients with long-term pronation. By classifying and staging the deformity, as well as understanding its plane of compensation, accurate clinical evaluation and diagnosis can lead to specific treatments to reduce pain and achieve adequate ambulatory function. In general, the surgical treatment of an endstage flatfoot sacrifices joint motion for comfort. However, other procedures can be implemented which are even more effective at preserving function.

BIBLIOGRAPHY

Miller SJ: End-stage Flatfoot: Diagnosis and Conservative and Surgical Management. *J Am Podiatry Med Assoc* 77:1, 1987.