Lateral ray stress fractures are a known complication of the cavovarus foot deformity. Malpositioning of the forefoot and hindfoot leads to increased pressure on the heel and lateral rays, resulting in significant morbidity. Patients with nonprogressive deformities can be managed surgically or nonsurgically in an attempt to decrease adverse events. It is often difficult to predict which patients will benefit most from a surgical intervention. This article describes 2 model cases of stress fractures in patients with nonprogressive cavovarus foot deformities. Patient 1 was an active patient with a minor, flexible cavovarus deformity, and patient 2 was a relatively inactive patient with a severe, fixed deformity.

These cases serve to illustrate a spectrum of the 2 major risk factors for the development of a stress fracture of the lateral rays: severity of deformity and activity level of the patient. We believe the relationship between these 2 risk factors constitutes a threshold that allows the development of a stress fracture to serve as an adequate marker for surgical intervention. Within this patient population, a stress fracture indicates that given a patient’s lifestyle, his or her deformity is sufficient enough to cause significant and repeated morbidity. Surgical restoration of the foot to plantigrade will eliminate the increased forces to the lateral metatarsals and decrease the incidence of further injury. Thus, stress fractures of the lateral rays in patients with nonprogressive cavovarus deformities should be considered an indication for surgical intervention.

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es cavovarus is a deformity characterized by an elevated medial longitudinal arch resulting from first ray plantarflexion, forefoot pronation, and hindfoot varus. Due to the altered anatomy and mechanics of the cavovarus foot, forces are not adequately distributed during weight bearing and physical activity. The high arch, forefoot pronation, and hindfoot varus cause the foot to assume a tripod position, which increases stress along the heel and lateral rays. This can lead to painful callosities, frequent ankle sprains, and stress fractures of the lateral metatarsals.

With multiple etiologies and an array of available treatments for the cavovarus foot, evaluation of the patient must be thorough and comprehensive to guide the physician’s numerous management options. Surgical procedures are generally pursued in patients with progressive disorders or those who have symptomatic deformities affecting quality of life and basic function. However, there are no absolute indications for surgical intervention in nonprogressive cavovarus deformities. Such decisions are often made based on the surgeon’s personal experience and the patient’s physical tolerance of the deformity. Furthermore, it is possible for patients with nonprogressive deformities to experience effective symptomatic relief through nonsurgical management, either delaying or avoiding surgery altogether. Therefore, deciding when to take a patient with a nonprogressive deformity to the operating room can be challenging.

A review of our patient population from the inception of computerized charting in January 2005 found 74 patients with cavovarus deformities being followed in our clinics. Of these patients, 37 were ultimately managed surgically with procedures ranging from plantar fascia releases to triple arthrodesis. During this time frame, 4 patients were found with stress fractures of their lateral metatarsals. Of these 4 patients, 1 developed a fifth metatarsal stress fracture secondary to frequent soccer playing and had no appreciable foot deformity. The other 3 had no specific inciting causes for the development of a lateral ray stress fracture but were found to have varying severity levels of cavovarus deformities.

This article describes 2 representative patients with the least severe and the most severe nonprogressive, cavovarus deformities who developed stress fractures of their lateral rays. The implications of such a finding suggest that stress fractures in patients with nonprogressive cavovarus deformities should be considered an indication for surgical intervention.

**CASE REPORTS**

**Patient 1**

A boy born with cerebral palsy and bilateral cavovarus deformities underwent bilateral teno-Achilles lengthening and bilateral midfoot osteotomies at age 7. The patient continued to have mild residual cavovarus positioning but remained active, participating in sports for the next 7 years without incidence.

At age 15, he presented with right knee pain that was determined to be Osgood-Schlatter disease. During this visit, examination of the feet revealed calluses on the lateral borders and a flexible heel varus. It was decided to attempt to relieve pressure on the lateral borders of the feet through use of heel orthotics.

Two months later, the patient returned to the clinic reporting that he had not been wearing the orthotics and was now experiencing significant pain on the lateral side of his right foot. Radiographs at the time determined that he had sustained a stress fracture of the fourth metatarsal (Figure 1). Following healing of the fracture, the patient underwent right midfoot osteotomy with lateral column shortening and medial column lengthening.

Five-month follow-up revealed a plantigrade foot with only mild to moderate pain diffusely distributed across the foot. The pain did not subside in the next 3 months, and radiographs revealed mild subtalar arthrosis. The patient received a subtalar steroid joint injection, and a month later he was able to return to full activity. By his final follow-up visit 1 year later, he was playing full-time for his high school soccer team without pain in his foot.

**Patient 2**

A boy born with hydrocephalus and a left cavovarus deformity secondary to complications associated with a motor vehicle collision while in utero underwent teno-Achilles lengthening at age 7 in Mexico. At age 9, revision teno-Achilles lengthening was required, as well as posterior tibial tendon transfer in a repeated attempt to plantigrade the foot.

Three years later, on initial presentation to the Shiners Hospital for Children in Los Angeles, physical examination revealed a residual deformity with fixed cavovarus positioning. The patient was scheduled for surgical correction via triple arthrodesis. At admission, radiographs revealed an unhealed fracture of the proximal fifth metatarsal that prevented surgery (Figure 2). The fracture was allowed to heal, and triple arthrodesis was successfully performed 3 months later. His postoperative course was unremarkable and the foot was deemed plantigrade on subsequent clinic visits.

The patient was followed for 2.5 years, during which time he had no complications.
DISCUSSION

Stress fractures have been defined as “spontaneous fractures of normal bone which result from the summation of stresses, any of which by themselves would be harmless.” Repeated mechanical loads lead to cortical resorption and remodeling of bone. If adequate time is not given to recovery, cumulative microtrauma may result in a stress fracture. In the plantigrade foot, stress fractures are most common among highly active individuals such as distance runners, military personnel, and dancers. Among this population, the overwhelming majority of stress fractures occur in the second and third metatarsals. Since only a small subset of these highly active persons eventually develop stress fractures, many studies have investigated other possible predisposing factors. Characteristics such as age, sex, skeletal alignment, low bone density, hormonal environment, muscle fatigue, and type of footwear, as well as biomechanical aspects such as external rotation of the hip, leg-length discrepancy, high longitudinal arch, pronation of the ankle, and varus alignment of the ankle and forefoot, have all been implicated as possible risk factors. Certainly, many of the aforementioned attributes play a role in determining one’s overall risk. However, the 2 overarching aspects remain the repetitive forces subjected to the foot and the shape it assumes when absorbing these forces.

A study by Gross and Bunch examined the pressures exerted on each metatarsal during the act of running. Not surprisingly, they found that the plantigrade foot experiences peak stresses over the second and third metatarsals. This correlates with the high incidence of stress fractures found in those bones. Although no studies have quantified forces on the cavovarus foot, it is not a stretch to reason that stress would be drastically increased, if not greatest, along the fourth and fifth metatarsals. Hindfoot varus causes ambulation on the lateral border of the foot and overloads the fourth and fifth rays. In addition, hindfoot inversion, forefoot supination, and a high arch lock the foot, making it more rigid and less effective at stress dissipation. An increased load along the lateral border of the foot coupled with a decreased ability to dissipate strain predisposes the cavovarus foot to stress fractures of the lateral metatarsals. Thus, the development of a stress fracture of the lateral rays depends primarily on 2 factors: severity of the deformity and activity level of the patient. The more dramatic the heel varus and forefoot supination, the more strain is placed on the lateral rays. Thus, with increased forces acting on the foot per contact, less activity is required to induce a stress fracture. This is best demonstrated by patients who lead a sedentary lifestyle but have sufficiently severe deformities such that the increased forces on the foot are enough to cause a stress fracture despite relative lack of activity (patient 2). The opposite holds true for active patients with a comparatively minor deformity (patient 1). In this situation, the principal of stress fracture development remains similar to the plantigrade foot. However, repetitive strain applied to the laterally predisposed cavovarus deformity preferentially leads to stress fractures of the fourth and fifth metatarsal, rather than the second and third.

We believe the relationship between deformity severity and activity level constitutes a threshold that allows the development of a stress fracture to serve as an adequate marker for surgical intervention. For patients with a cavovarus foot deformity, a stress fracture indicates that for a given lifestyle, their deformity is sufficient enough to cause significant and repeated morbidity. This allows the objective finding of a stress fracture to help dictate the treatment plan of an otherwise subjective appraisal of benefit versus harm. Surgical restoration of the foot to plantigrade will eliminate the increased forces to the lateral metatarsals and decrease the incidence of further injury. Thus, stress fractures of the lateral rays in patients with nonprogressive cavovarus deformities should be considered an indication for surgical intervention.

REFERENCES