CASE STUDY:
Metatarsal Stress Fracture

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INTRODUCTION

Forefoot pain with the subsequent diagnosis of metatarsal stress fracture is a common clinical situation that arises in the podiatric office. Stress fractures were first described in military recruits undergoing basic training, as a partial or complete osseous fracture that resulted from repeated stress (Donahue et al., 1999). Despite the frequency of lesser metatarsal stress fractures the exact etiology remains unclear. There are a number of factors that may contribute to an alteration of normal bone physiology and an ultimate failure under stress including:

1) alterations in weight-bearing activity
2) abnormal lower extremity biomechanics
3) overall bone health

Regarding biomechanical etiology, one possible mechanism could be that of an increase in axial mechanical stress on the metatarsal secondary to: a long second metatarsal, a hypermobile first ray, and/or excessive midstance STJ pronation.

A second possible etiological factor is foot intrinsic and extrinsic muscle fatigue. Muscular fatigue may lead to a deficiency in shock attenuation and/or an incessant compression loading under the foot (Weist et al., 2004). Simply put, it is postulated that stress fractures occur in normal bone due to mechanical overload by cyclical stress that causes osteoclastic activity at a greater rate than osteoblastic activity resulting in microfractures (Knobloch et al., 2006).

Let's look at a case study that may help delineate the different etiologies, along with proper diagnosis and treatment of a lesser metatarsal stress fracture.

CASE STUDY

History:

A 45 year old white female presented to the clinic with increasing pain in the distal portion of her right forefoot. During long walks, the symptoms had progressed from a dull ache to a constant more severe and localized pain. She had recently doubled her long daily walks from 2 to 4 hours.

Her past medical history revealed that she was post-menopausal and otherwise in good general health. She had been under the care of her physician for unrelated problems in the past two years and related to a past medical history of knee surgery, kidney stones and has allergies to penicillin and Demerol. She had a family history of rheumatic fever, denied tobacco or alcohol use, and her review of systems was unremarkable.

Physical:

The patient was 178cm in height, 64kg in weight and wears a ladies size 10 shoe. Examination of her integument revealed a callosity beneath the second metatarsal on the right foot. The vascular and neurological exams were within normal limits, except for non-pitting edema over the distal one third of the second metatarsal shaft which obscured visualization of the long extensor tendons. There was focal and discrete palpable pain both dorsally and plantarly over the second metatarsal.

Testing:

Radiographs were performed and revealed no osseous abnormality (Figure 1). A triple phase technetium bone scan was then ordered and revealed a stress fracture of the second metatarsal right foot (Figure 2).

Figure 1

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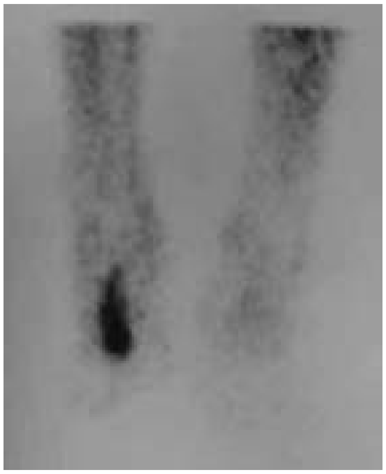


Figure 2

Treatment:

Due to the severity of pain, ice and oral anti-inflammatories were initially recommended along with an ankle high removable walking cast. The cast was worn for 2 weeks and the acute symptoms subsided. She was then instructed to wear her stiff soled mountain biking shoes for 2 weeks and began stationary cycling and core exercises. Symptoms continued to improve and at 6 weeks post injury she was back into her comfortable walking shoes and at 8 weeks post injury was 95% improved.

Figure 3

A follow-up radiograph was performed and callus formation was noted. Further tests were undertaken to inquire about the etiology of the injury (Figure 3). A gait and pressure analysis was performed that showed biomechanically increased pressure beneath the second metatarsal and excessive midstance subtalar and midtarsal joint pronation. She was referred back to her family doctor for bone density testing which came back normal for her age.

The last stage of her treatment involved addressing the two most obvious etiologies: 1) an aggressive increase in activity, and 2) biomechanical stresses on the second metatarsal.

She was instructed not to increase her weekly mileage by more than 10%. A custom foot orthotic was fabricated to control the unstable midstance motions that may have been contributing to fatigue in the intrinsic and extrinsic muscles and to reduce pressure on the second metatarsal.

The following are features of this orthotic (Figure 4):

1. Semi-rigid polypropylene shell with intrinsic forefoot posting and extrinsic rearfoot posts
2. Cushioned neoprene top cover
3. Cushion cork accommodation sub-second metatarsal
4. A metatarsal pad was added at a later date

Figure 4

Lastly, an appropriate walking exercise shoe was prescribed with good midsole cushioning and forefoot rocker. Shoes can be further modified as needed to increase forefoot rocker and to stiffen the forefoot.

Discussion:

The amount of immobilization needed to efficiently heal a stress fracture is relative to the severity of symptoms and the etiology of the problem. It is often effective to simply remove the patient temporarily from the causative activity and wear supportive good walking shoes. For patients that have rigid mountain biking shoes, wearing this type of footwear may lead to symptomatic relief. This is not unlike the graphite-type spring plate that is often used in conventional shoes. In fact, recent studies have shown that second metatarsal stress is increased with more flexible shoes (Arndt et al., 2003). Simply put, it is important to ask patients to monitor their stress.

Pressure analysis can be a good method of assessing or substantiating some of the biomechanical etiologies for this condition after the patients gait returns to its pre-injury state (Carmont et al., 2006). Stress fractures require prompt diagnosis, along with the willingness to adapt multiple strategies to each individual patient, and appropriate referral back to the family physician for medical management of the problem including bone density.

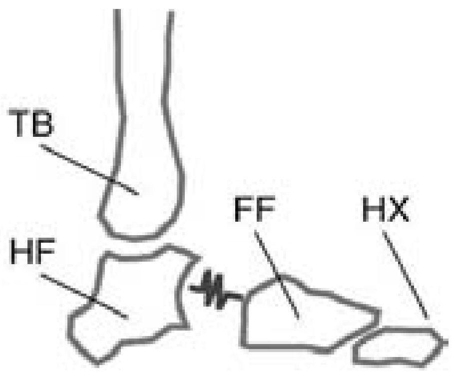
CLINICAL BIOMECHANICS:
Forefoot Dynamics and Injuries

By Christopher MacLean, Ph.D. (Candidate)

INTRODUCTION

Interestingly, it has only been recently that we have been able to measure the motion of the forefoot in 3-dimensions during walking. The reasons for this have been mainly technological limitations in what biomechanists have been able to actively track in kinematic analyses. Until the late 1990's, most kinematic studies have focused on rearfoot motion and modeled the foot as a single rigid segment. More recently, the foot has been modeled as a multi-segmented structure allowing for biomechanists to measure the movement of the forefoot relative to: the rearfoot, the leg and the laboratory.

The forefoot has been defined as the region of the foot that is distal to the tarsometatarsal joints. Included in this region of the foot are the 5 metatarsals, 14 phalanges and 2 sesamoid bones. In order to measure forefoot kinematics, the researcher must position a cluster of markers on the rearfoot (HF) and on the forefoot (FF) (Figure 1).



FOREFOOT KINEMATICS

The gait cycle can be broken down into the swing and stance phases. For the purpose of this commentary, we will only focus on the stance phase. The stance phase has four notable events including: 1) foot contact (0% stance), 2) flat foot (~20% stance), 3) heel rise (~60% stance), and 4) toe-off (100% stance).

At foot contact, the forefoot everts, abducts and dorsiflexes relative to the rearfoot. Forefoot eversion and abduction occur rapidly and reach their maxima at approximately foot flat (~15-20% stance).

From foot flat, the angles are maintained until immediatrely following heel rise (~70% stance) when the forefoot rotations reverse and the forefoot inverts and adducts to toe-off. Concidentally, the forefoot dorsiflexes relative to the rearfoot throughout stance until it reaches its maximum immediately after heel rise (~ 70% of stance). Following this peak angle, the forefoot plantar flexes until toe-off.

FOREFOOT INJURIES

Some of the most common forefoot injuries include: 1) metatarsal stress fractures, 2) interdigital neuromas, 3) sesamoid pathology, 4) hallux rigidus and limitus, 5) metatarsalgia, and 6) turf toe.

Metatarsal Stress Fractures

A stress fracture is a break in the bone that develops after cyclical, submaximal loading. In states of increased physical activity, bone is resorbed faster than it is replaced. The result is a physical weakening of the bone and the development of microfractures. With continued stress, microfractures unite to become a stress fracture. A stress reaction may proceed a full blown fracture when the microfractures are attempting to heal.

The most common etiological factor in the occurence of metatarsal stress fractures is an abrupt increase in activity intensity whether it be an increase in mileage and/or time spent in high impact sport. In addition, metatarsal stress fractures have been reported to be most common in runners but are also prominent in aerobics, racquet sports and basketball.

Interdigital Neuroma

An interdigital neuroma, or Morton's neuroma, is a mechanical entrapment of an interdigital nerve. The interdigital nerves trace inferior to the transverse intermetatarsal ligament and are vulnerable to traction and compression injuries at the distal aspect of the ligament. Patients will present with complaints of a forefoot burning sensation, cramping, paresthesia and numbness. The symptoms will often be relieved by simply removing the footwear and massaging the foot.

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