

Management of Metatarsalgia Secondary to Biomechanical Disorders

A Case Report

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Metatarsalgia is defined as pain in the anterior segment of the foot.¹ Viladot stated that it is one of the most common types of pain.² Symptoms of metatarsalgia include: pain and tenderness of the plantar surface of the heads of the metatarsal bones or of the metatarsophalangeal joint,³ development of callus under the prominent metatarsal heads,⁴ and increased pain during the mid-stance and propulsion phases of walking as body weight is shifted forward onto the forefoot. Patients often will omit the propulsion phase from the walking cycle to reduce the degree of pain.

The most frequent cause of metatarsalgia is an alteration of the normal biomechanical functioning of the forefoot.² Metatarsalgia also can occur secondarily to a traumatic episode or a systemic condition including rheumatoid arthritis, neurological disease, and vascular disease.^{5,6}

Previous explanations for metatarsalgia caused by altered biomechanical functioning have focused on a depression or "dropping" of the anterior transverse arch.^{2,7} This disorder would cause increased weight to be borne by the middle metatarsals (second, third, and fourth) resulting in the signs and symptoms.⁷ The treatment frequently prescribed is the metatarsal pad, which is designed to lift the middle metatarsals back into the normal curvature of the anterior transverse arch.^{4,7} This concept of the depressed middle metatarsals causing metatarsalgia might be valid if the weight were borne only by the first and fifth metatarsal heads. Studies, however, have demonstrated that during

weight bearing all metatarsal heads are in contact with the supporting surface.^{5,8,9} Although the distribution of weight may vary among the five metatarsals during the walking cycle, all metatarsal heads come in contact with the ground.⁸

Root et al stated that the most common cause of the faulty biomechanical functioning leading to metatarsalgia is abnormal pronation of the subtalar joint.⁵ This joint normally pronates during the first 15% to 20% of the stance phase (contact phase) to absorb lower limb rotation and shock.⁵ In addition, pronation of the subtalar joint allows the midtarsal joint axes to become parallel so that the bones of the foot can be mobile to adapt to uneven terrain. At the end of the contact phase, the subtalar joint supinates, causing the axes of the midtarsal joint to converge. This convergence increases through the mid-stance phase so that at heel-off a rigid foot structure has been achieved.⁵ For a more detailed explanation of the functional biomechanics of the foot during walking, the reader is referred to Root et al⁵ and McPoil and Brocato.¹⁰

The normal conversion of the foot from a mobile to a rigid structure can be delayed if an osseous abnormality such as a forefoot varus deformity exists within the foot.¹¹ The presence of a forefoot varus deformity can prolong the period of subtalar joint pronation, causing the patient to push-off on a hypermobile foot structure. As weight is shifted from the lateral to the medial aspect of the foot in preparation for toe-off, the first ray cannot support the normally borne weight and, therefore, moves vertically because of the hypermobility. This movement causes increased weight load on the second, third, and fourth metatarsal heads immediately after heel-off.

The forefoot also is subjected to simultaneous linear and transverse shear

forces created by lower limb rotation.⁵ Thus, when an abnormally pronated, hypermobile foot enters the propulsion phase, the increased shear and vertical forces traumatize the plantar tissues of the second, third, and fourth metatarsal heads because the first ray is unstable. Continued stress with each step leads to pain and to callus development under the second, third, and fourth metatarsal heads. Viladot referred to this mechanism as one of the causes of first ray insufficiency syndrome and noted that the most common cause of pain in the forefoot is a disruption of normal biomechanical functioning.² Functional orthotic devices have been used to control abnormal subtalar joint pronation and, thus, to decrease hypermobility in the foot complex.¹²⁻¹⁴ The purpose of this case report is to demonstrate the effectiveness of using orthotic devices to alleviate the symptoms of metatarsalgia secondary to faulty foot biomechanical functioning.

PATIENT HISTORY

A 55-year-old woman, weighing 61.2 kg and having a height of 170.2 cm, was referred to the physical therapy clinic for an examination. She reported a two-year history of pain in her left foot, which began without trauma and developed gradually. Although she experienced varying degrees of pain, the severity of the pain had increased during the last four to six months. Other symptoms included marked tenderness on palpation under the second and third metatarsal heads and callus formation in the same location. She demonstrated a decreased stance phase on her left side and stated that her maximum tolerance for standing before the onset of her symptoms was only 30 minutes. The patient explained that she was extremely frustrated by her lack of physical activity imposed by her foot pain.

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The patient's previous treatments included two cortisone injections to the area of pain (about four months apart) and oral anti-inflammatory agents. A commercial arch support, consisting of a medial longitudinal arch support and a metatarsal pad, had been prescribed previously. Although the patient reported three to four weeks of pain relief after each injection, the symptoms reappeared with increased intensity. The oral anti-inflammatory drugs and the arch support provided no symptomatic relief.

EVALUATION

The results of a neurological examination of the patient's lower extremity myotomes, dermatomes, and reflexes were within normal limits. Muscle strength throughout both lower limbs was normal. Screening results of the patient's lumbar spine, sacroiliac, and knee joints were negative in regard to pain and quality of movement. The bilateral range of motion of the patient's hip joint was 45 degrees of external rotation and 40 degrees of internal rotation with the patient in a prone position and with her knees flexed. All other bilateral motions of the hip and knee joints were within normal limits.

The remaining portion of the examination, involving the foot and ankle joints, was identical to that described by McPoil and Brocato.¹⁰ We found that the patient's bilateral malleolar torsion was within normal limits. Bilateral dorsiflexion of the talocrural joints with the knees extended and the subtalar joints in the neutral position was 10 degrees; bilateral dorsiflexion of the talocrural joints with the knees flexed was 15 degrees. The subtalar joint pronation was 12 degrees in the left foot and 10 degrees in the right foot. Subtalar joint supination was 25 degrees, bilaterally. No rear-foot varus deformity existed in either foot. All of these measurements are considered to be within normal limits. A forefoot varus of 10 degrees, however, was measured on the left side, and 1 degree of varus was measured on the right side when the subtalar joint was in a neutral position. When the subtalar joint is in a neutral position, a forefoot

varus of 1 to 2 degrees is considered normal.¹⁵ When the patient assumed a standing position, the calcaneus was neutral in the right foot and everted 8 degrees in the left foot.

A visual assessment of the patient's walking pattern revealed no push-off on the left side. The patient's stance period was decreased and we observed excessive subtalar and midtarsal joint pronation throughout the stance phase in the left foot.

TREATMENT

Long-term management of metatarsalgia for this patient required a functional orthosis for the left foot to prevent abnormal pronation throughout the stance phase. An orthotic device also was fabricated for the right foot to ensure comfort and to prevent any leg-length discrepancy secondary to the orthosis in the left shoe. Plaster casts were taken of both feet, with the subtalar joint in the neutral position, during the initial treatment to fabricate the foot orthoses. The neutral casting and fabrication of the orthotic devices were performed by one of us (T.G.M.) using procedures previously described.¹⁰ The only modification to this fabrication technique was the use of Nickelplast* for the posting or balancing layer. We have found Nickelplast to be preferable for use with older patients because it is less rigid, but maintains its shape and resists flattening.

To obtain temporary relief from symptomatic pain during the two-week fabrication period, the patient used a metatarsal bar and a Spenco† insole. The former device decreases the pressure on the metatarsal heads; the latter device reduces shear stress and plantar pressure.

The patient returned to the clinic after two weeks for fitting of the functional foot orthoses. The left orthosis was fabricated to correct the patient's forefoot

varus deformity. The patient reported that the initial treatment procedures had resulted in an estimated 30% reduction of her symptoms within the first four days but that she had not noticed any further improvement. The metatarsal bar was removed from the outsole of her shoe, and the orthoses were placed inside the shoes. After the correct orthotic fit was determined, we instructed the patient in the proper break-in and care of the orthoses. After three weeks, the patient reported that her symptoms were reduced by an estimated 80%. On clinical observation, we found that her walking pattern, including push-off, had improved noticeably. The patient also reported that she could stand and ambulate for five continuous hours without pain. After two months of wearing the foot orthoses, she stated that her symptoms had disappeared completely. A reevaluation of her walking pattern revealed a symmetrical stance phase with a complete bilateral push-off. During a six-month follow-up examination, the patient stated that she had not experienced any reoccurrence of symptoms and was using the foot orthoses in a variety of oxford shoes.

DISCUSSION

The intent of this case report was to illustrate the importance of considering the biomechanical causes of dysfunctions rather than just treating a patient's symptoms. Although the physical therapist can use physical agents, metatarsal bars, or pads for the treatment of dysfunctions, such modalities and appliances can provide only temporary relief of symptomatic pain. Successful long-term management of pain cannot be expected unless the actual cause of the patient's symptoms is determined.

We realize that numerous designs and materials are available for orthosis construction and that only one fabrication technique was used in this study. Regardless of the orthosis fabrication technique chosen, however, the effectiveness of any functional foot orthosis is dependent on the ability of the clinicians to identify abnormal biomechanical conditions existing in the foot complex.

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