Equinus and the Diabetic Foot

Understanding the underlying biomechanics is the key to successful treatments.

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Introduction

For the podiatrist, the diabetic foot is a difficult challenge that is ever-changing and requires constant vigilance. Our understanding of its dynamics and of the biomechanical changes that are secondary to other co-morbidities is a continuing challenge; and exacerbating these problems is the dramatic and ever-escalating prevalence of the disease, which perhaps should be no surprise considering our sedentary lifestyle and our increasing reliance on digital media.

A 2016 study of the leading causes of death in America published by the CBC and Health and Human services shows that diabetes was the seventh leading cause of death in the United States, responsible for just over 76,000 recorded deaths.[11] It was also listed in 245,000 documented deaths as a contributing factor.[11] The total of direct and indirect costs to our economy in the U.S. for care of diabetes numbers around $174 billion.[11]

It has been noted that 25% of diabetic patients will develop an ulcer to the lower extremity.[13] Proper podiatric care for diabetic patients for the lower extremities can have a dramatic impact on healthcare costs across the board in the amount of about $3.5 billion—*additional* to the previous staggering statistics.[13] Some of the most commonly documented areas of ulceration/pressure in the forefoot are to the heads of the plantar metatarsal, the distal digits secondary to contractures, the plantar medial aspect of the IPJ of the hallux, and the dorsal aspect of the interphalangeal joint of the lesser digits.[13] While these areas may be the heightened sense of our concern for treatment, we need to look at how we can prevent these areas from breaking down or developing problems. The one problematic constant in the podiatric biomechanics of the gait cycle is the limitation of the foot at the level of the ankle secondary to posterior muscle contracture, better known as equinus.

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An article published in the *Journal of the American Podiatric Medical Association* in 1995 stated that 96.5% of the author's patients seen in clinic had reduced dorsiflexion of the foot at the level of the ankle, requiring compensation through the gait cycle.[14] Other authors, such as Patel and DiGiovanni, produced statistics when evaluating patients with chronic and acute plantar fasciitis.[3] It was documented that 83% of their patients were diagnosed with the deformity and 57% of these patients were diagnosed with a deformity as an isolated incident for treatment.[3] In the diabetic patient, this overload to the forefoot due to the change in biomechanics can have significant long-term effects such as pre-ulcerative lesions, ulceration formation, progression of Charcot deformity, and a number of other contributing factors.

Identifying and Examination

Identification of biomechanical problems in a patient is priority number one to ensure proper treatment long-term. The Achilles tendon is the thickest, strongest tendon within the human body and serves as an insertion for both the gastrocnemius and soleus muscles to the posterior aspect of the calf. From about the mid-calf area to its insertion, it measures about 15 cm in length. The soleal muscle lies deep, or anterior to the gastrocnemius muscle and arises from the back of the head of the fibula, the upper third of the posterior surface of the fibula, and the soleal line of the middle third of the tibia.

The gastrocnemius muscle is the most superficial muscle of the group and forms the belly of the calf. What is important about this muscle is the fact that its origin begins on the facets above the femoral condyles. The plantaris muscle also crosses the knee and finds its origin on the femoral condyle. Both gastrocnemius and

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the plantaris muscles are considered as three joint muscles as opposed to the soleal muscle, which is considered a two joint muscle.

The understanding of the anatomy is important for the administration of the clinical examination in order to determine if the patient has a deformity present. Numerous articles have documented the biomechanics of these muscles through the gait cycle. In their article, *Normal and Abnormal Function of the Foot: Clinical Biomechanics* from 1977, Root and colleagues attempted to describe the forces acting upon the foot during locomotion.[5] They discussed that the gastrocnemius and soleal muscles normally begin to contract toward the end of the contact period of the stance phase of gait. The muscle then continues to contract throughout the mid-stance period and through the first portion of the propulsive period.[5]

This understanding of the contracture of the muscles through the gait cycle is what is most important for the physician in the assessment. There are several definitions of equinus documented in the literature, but the classic definition is usually described as a limitation of the ankle joint dorsiflexion to less than 90° of the foot on the leg. The classic clinical method for evaluating equinus is the Silfverskiold test. This clinical test describes dorsiflexion of the patient's foot at the level of the ankle while in neutral position with both the knee flexed and the knee extended. The physician is supposedly then able to include or rule out which muscles are affecting the deforming forces of the condition. Therein lies the problem for the clinical examination.

The physician is concerned with the ground reactive forces in relation to the diabetic foot. Through the gait cycle, the gastrocnemius and soleal muscles are only active through the end of the contact period of the stance phase of gait, through the mid-stance, and through the first portion of the propulsive period. The testing of the passive range of motion of the ankle with the knee flexed has no bearing on the true understanding of the ground reactive forces through the stance phase of gait for treatment of the diabetic patient. Proper assessment of the patient's lower extremity should be with the knee extended.

Next, inversion of the heel should be made with the physician's free hand to secure the rear foot. It must be noted that most physicians at this time will grab the distal forefoot with the other free hand to begin dorsiflexion. This technique is wrong due to the fact that there will be movement within the mid-foot that can give a false negative. The physician's free hand should begin dorsiflexion at the mid-foot with securing of the navicular and mid-tarsal joints with inversion of the forefoot to lock the mid-tarsal joints. This will give the position and accurate depiction of the patient's true deformity.

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Co-Morbidities

The physician's assessment of the patient's equinus should also be addressed not only in the anatomical sense, but also considered in terms of the patient's metabolic state as well as the current neuropathic condition. Lavery and colleagues, in 2002, published an article in *JAPMA* looking at ankle equinus and its relationship to high plantar pressures in the diabetic patient.[12] It was noted that 10.3% of their 1,666 test subjects were shown to have equinus. Of those, subjects showing the deformity proved three times the greater risk of presenting with elevated plantar pressure. One of the more interesting findings of this paper is that the patients with the noted equinus had a longer diagnosis history of diabetes than those who did not. Lavery and colleagues determined that non-enzymatic glycation and significant abnormalities of fibrillar density and fibrillar diameter of the Achilles tendon lead to shortening of the gastrocsoleus complex.[12]

Because of the findings of this study, the podiatric physician needs to consider factors of clinical assessment, but also the length of the patient's diabetic condition to better aggressively treat the patient's equinus. The other concern related to equinus is how the patient's neurological status affects gait abnormalities. An article by Katoulis and colleagues published in *Diabetic Care* in 1997 looks at the effects of diabetic neuropathy on gait abnormalities.[9] The following gait parameters were investigated: 1) walking speed; 2) stance phase duration; 3) joint angles and moment arms for the ankle, knee, and hip joints in both sagittal and frontal planes; 4) the components of the ground reaction force (GRF) vector; and 5) the ankle, knee, and hip joint moments originating from the GRF vector in both planes.

Walking speed was significantly slower in the group of diabetic neuropathic patients with history of ulceration compared with the two control groups. The maximum knee joint angle was smaller in the sagittal plane for the diabetic neuropathy patient with history of ulceration group compared with the non-neuropathic diabetic group values. The maximum value of the vertical component of GRF was found to be higher in the two control groups compared with the diabetic neuropathic patients with history of ulceration group.[9] This article ties in very well with Lavery's article showing that the metabolic effects on the tendons of the diabetic patient along with the neuropathic component can have significant effects on gait abnormalities, thus leading to ulcerations and various other conditions.

Treatment

Understanding of the problem leads to its identification in the diabetic patient; however, once these steps are met, the debate turns to what is the proper treatment. There will always be the constant argument of sur-

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gical versus conservative treatment when approaching equinus deformity, especially in the diabetic patient. Based on the findings of many of the articles discussed here, immediate conservative treatment for the diabetic patient seems like the logical answer. Whether newly diagnosed with diabetes or diabetic for 10+ years, a strong stretching or exercise program should be implemented for the patient. This would suggest referral to a local physical therapist to properly monitor the patient or to even get a baseline of the patient's general parameters related to the passive ankle dorsiflexion.

Equinus Brace

Incorporated into the clinical treatment, it can be beneficial to utilize an equinus brace for the patient. The issue when utilizing these types of braces is deciding what is the correct brace to use. The majority of the braces present as either anteriorly dorsiflexing the foot or posteriorly dorsiflexing the foot, depending on its configuration. Whether anteriorly or posteriorly dorsiflexing the foot, many of these devices are constructed to provide a midcalf support. This is where our understanding of the anatomy as previously described becomes a factor.

Because of our concern with the diabetic patient through the gait cycle, a device used for stretching of the posterior muscle groups must enable knee extension and keep the knee extended while stretching. Most of the devices utilized through the podiatric community do not. The IQ Medical equinus brace is one such conservative brace that does allow for extension past the knee proximally, stabilizing the lower extremity to get a true stretch of the triceps surae and the Achilles tendon. The amount of time that the patient should stretch is deferred to the physician or physical therapist.

Surgical Treatment

Surgical treatment for the patient depends on the nature of the condition of the equinus and the related co-morbidities. The gastroc recession or tendo-Achilles lengthening will forever be debated through the literature as the correct approach. Those considerations from a neuropathic standpoint as well as a metabolic state for the patient should be considered when choosing surgical intervention for the patient. There is no right or wrong for choosing a Strayer gastroc recession, tongue and groove, or a Vulpius and Stofell technique, etc. The choice of technique comes down to the comfort level of the surgeon and what works in their hands. The surgical treatment of the equinus deformity must always be considered as a secondary procedure when dealing with Charcot patients, arthrodesis of any type toward the rear foot, ulcerations to the forefoot, and amputation. Evidence-based medicine has time and time again shown us the effects of the posterior calf muscles on the distal forefoot related to these various conditions.

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Conclusion

The vital components for treating the equinus deformity and a diabetic patient involve understanding of the biomechanics, the proper examination, further clinical work-up related to the patient's other co-morbidities, and surgical consideration when necessary. A physician's careful clinical work-up and aggressive conservative care can be the difference maker for the diabetic patient's clinical outcome. **PM**

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