Reduction of Ankle Equinus Contracture Secondary to Diabetes Mellitus with Dynamic Splinting

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Introduction: *Ankle equinus is a hereditary or acquired contracture of the triceps surae or shortening of the connective tissue causing inability of the foot to dorsiflex during gait. For the patient population with diabetes mellitus, this high plantar pressure from contracture often results in ulceration. This is frequently treated by Achilles tendon lengthening which helps to avoid infection and amputation. The purpose of this study is to examine the effect of dynamic splinting in reduction of ankle equinus contracture for patients with diabetes mellitus.*

Methods: *A retrospective analysis was accomplished by reviewing the history of 48 patients following treatment with an ankle dorsiflexion dynamic splint. This dynamic splinting modality delivers low-load prolonged duration stretching while one sleeps. In this home therapy study, dynamic splinting was used for a mean 240 hours in the first month (5 weeks).*

Results: *Patients showed a statistically significant change in maximal ankle dorsiflexion ($P < 0.0001$). The patients mean, maximal active range of motion in dorsiflexion increased by 9° in the first month.*

Conclusion: *This modality proved effective as home therapy and should be examined in further research so that it may be employed as standard of care in treating ankle equinus contracture.*

Key words: Bilateral tension, Dynasplint, Home therapy, Rehabilitation.

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Ankle equinus is defined as the failure to achieve 10° of dorsiflexion during the gait cycle.[1-10] This disability is the result of contracture and has a significant prevalence in patients who have also been diagnosed with Diabetes Mellitus (DM), both Type 1 and Type 2.[1-4]

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Contracture by definition is the molecular shortening of connective tissue and is considered to be the underlying cause of this equinus.[2,3] Contracture of connective tissue is also evident in other pathologies causing other limitations in active range of motion (AROM).[13-19]

Diabetic neuropathy is an underlying neurological condition of ankle equinus contracture when the peroneal nerve is involved. Peroneal nerve atrophy allows the posterior muscle group to overpower the weakened anterior muscles.[3]

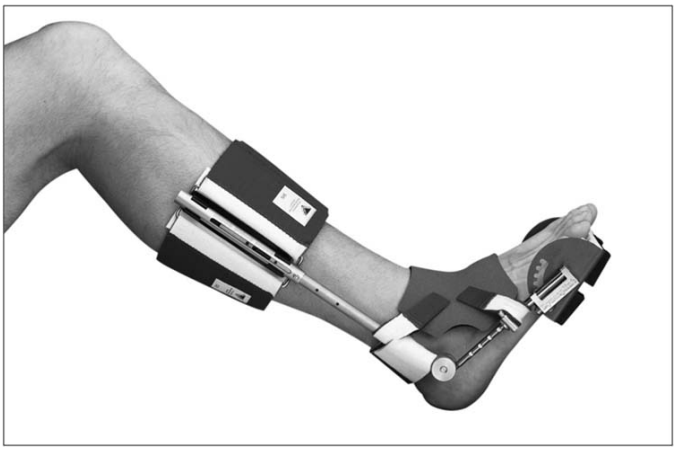

Figure 1 Ankle Dorsiflexion Dynasplint®.

In addition, plantar nerve neuropraxia or neurotemesis affecting the posterior tibial nerve (medial and lateral plantar nerves) causes a severe muscle imbalance between the larger and more powerful leg muscles and the intrinsic foot muscles. This contributes to the Lisfranc's dislocation typically seen in the Charcot diabetic foot. This is similar to the neuromuscular hypertonicity following a stroke which is commonly treated with Botulinium Toxin-A (tone management) and dynamic splinting (for contracture reduction).[13]

A study by Van Gils and Roeder showed the incidence of equinus deformity was present in 91% of patients with DM (n = 151, ages 51-95),[1] and a study of 1,666 DM patients by Lavery, et. al., showed 50.3% incidence of ankle equinus (All male; mean age 69 +/- 11 years).[2] National estimates from the American Diabetes Association list the current population of both diagnosed and undiagnosed DM to be 23.7 million Americans and the current "*Diabetes-related spending*" is $133 billion dollars in the USA.[20]

The current standard of care in treating ankle equinus includes shoe modification,[1] ankle mobilization therapy including passive stretching [1-4] and surgery (Achilles tendon lengthening, gastrocnemius recession, or tendon advancement procedures).[1,5,6,11]

The goal of all of these treatments is to prevent the need for amputation following uncontrollable infection from ulceration. The purpose of this study is to examine the effect of dynamic splinting in reduction of ankle equinus contracture for patients with DM.

The Ankle Dorsiflexion Dynasplint® (AFD) (Dynasplint® Systems, Inc., Maryland, USA) achieves a low-load, prolonged stretch to reduce contracture through increased time at end range (of motion).[13-19] The Dynasplint® units are worn at night (for 6-8 hours of continuous wear) while sleeping. The Dynasplint® modality has bilateral tension rods that allow for a tissue specific stretch. The device permits dynamic tension settings to be changed, which allow tension to be increased as the end range progresses and the deformity is reduced The AFD used in this study has been shown effective for treating excessive plantar flexion in stroke patients [13] and has shown similar efficacy for treating other conditions requiring contracture reduction.[14-19]

Methods

Records of patients with diagnosed ankle equinus, secondary to DM were used for this retrospective study. Patients' records who were treated with AFD were retrieved from multiple ankle and foot clinics in Georgia, Texas, and California. Maximal ankle dorsiflexion measurements were the dependent variable and these measurements taken with goniometry while the patient was lying supine with the knee fully extended. The 48 enrolled patients included 25 females and 23 males (mean age of 66 ± Standard deviation 11). The ethnic distribution included 7 African Americans, 4 Asians, 27 Caucasians, and 10 Hispanic patients.

Patients' initial introduction to the AFD, included customized fitting with consideration for the patient's foot size and varying degrees of edema which may be present. Patient training was instituted by the technician trained on the Dynasplint systems. Verbal and written instructions were provided throughout the duration of treatment for safety, general wear and care, and tension setting goals based on patient tolerance. (Fig. 1)

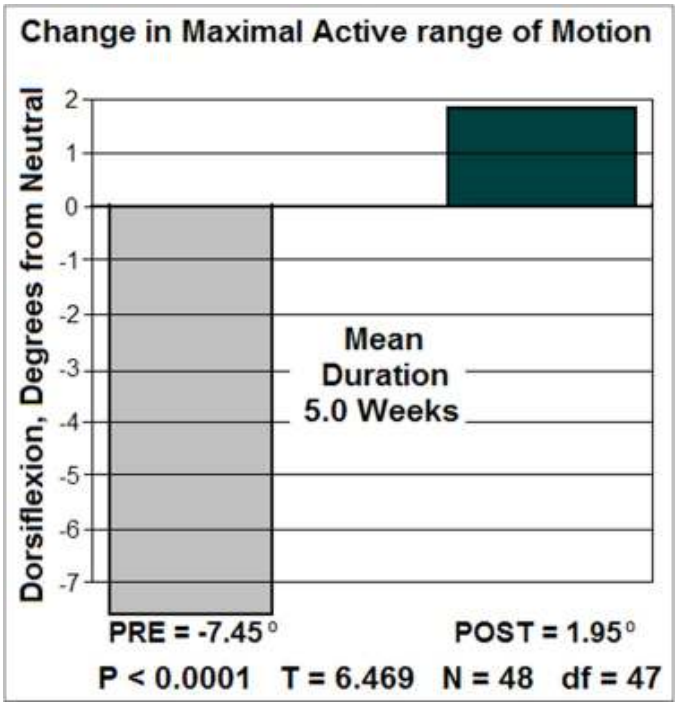

Figure 2 Mean change in active range of motion.

Each patient was instructed to start by wearing the AFD for a few hours before sleeping for one day, and then for 6-8 hours while sleeping using an initial tension setting of #1 (2.0 foot pound of torque). This initial frequency, intensity, and duration are used for patient acclimatization to the system. The patients were then instructed to increase the tension one increment every two weeks as tolerated. If the new tension gave the patient "*prolonged soreness or pain*" (defined as greater soreness than would occur after one hour of intense manual therapy), the patient was instructed to reduce the tension one half increment for a few days before returning to the new setting.

The duration for this study was five weeks. This period was selected to ensure 100% patient compliance and to avoid what one study reported as "*difficult (prolonged) follow up*." [4] However the AFD is routinely prescribed for six or more months in treating this condition.

Data Analysis

A paired t-test was calculated to determine if a statistically significant difference existed between the initial, maximal AROM and the final, maximal AROM. The calculations were done independently by an outside biostatistician, Dr Ram Shanmugam from Texas State University, San Marcos, TX.

Results

There was a statistically significant difference in the pre vs. post measurements of patients' maximal, AROM in dorsiflexion, ($p < 0.0001$, $t = 6.469$, $df = 47$, $n = 48$). The mean improvement was 20% in just one month. (Fig. 2)

Discussion

The purpose of this study is to examine the effect of dynamic splinting in reduction of ankle equinus contracture for patients with diabetes mellitus. Burke, et al., described hypomobility and diabetic ulcers saying "plantar-flexed first ray deformity (contracture) has been shown to increase pressure on the first metatarsal head and is associated with ulceration." [5] The AFD used in this trial reduced contracture using passive stretching similar to one component used in the study by Danaberg, et al. The Danaberg study included manual therapy "*Mobilization" and passive stretching or "assisted stretching*". The findings show an instant 4.9° improvement in maximal dorsiflexion.[4] Comparable passive stretching was delivered by the AFD but for substantially longer durations as it was worn for 6-8 hours wear during sleep. The AFD wear averaged 6.9 hours per night equaling a total of 241 hours of end range stretching. AROM measurements were taken several hours after awakening which showed stable improvement in contracture reduction.

Literature has shown a direct relationship between mechanical stress (positioning), foot ulceration, and surgery.[3,4,9] Research has also described connective tissue elongation from prolonged stretching [22] and sarcomere changes from limb lengthening.[23] The current standard of care, surgical resolution of ankle equinus contracture, has been established.[1-12] However, use of a modality like the AFD could prevent the need for surgery in a significant number of patients. A previous protocol of using serial casting has been discontinued for DM patients due to the great frequency of skin breakdown and ulcerations from the casting itself. There were no incidences of skin breakdown reported in this retrospective AFD study.

The limitations on this study include lack of a control group, but this study did have high external validity due to the retrospective design which recruited patient records completed before initialization of the study.[21] The study was also limited by its short duration. However, the study by Danaberg, et al., described that a shorter duration study was more likely to display results from the highest patient compliance. This five week study had 100% compliance in wear and tracking of this modality.[4]

Conclusion

Use of the biomechanically correct AFD® with bilateral, dynamic tension has proven effective in this study achieving a mean 9º increase in maximal, active range of motion in one month. This treatment method of dynamic splinting as a home therapy should be considered before surgery is implemented to reduce ankle equinus contracture. In addition, awareness by the physician of these potential damaging equinus factors would suggest early and immediate use of the device for prophylaxis. The normal prescription of this system is six months. A future experiment measuring changes from six month duration in a randomized, controlled trial would prove the efficacy of this modality.

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