Gait Analysis of a Man with Insidious Onset of Drop Foot, Comparing the Kinetics, Kinematics, and EMG Activity Wearing Two Different AFO: A Case Report

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Introduction

Insidious onset of drop foot is a common consequence of a low-back injury at the L4-L5 level. Traditional ankle-foot orthoses (AFOs), designed to provide dorsiflexion in the absence of pretibial muscle activity, are very rigid, bulky, and often uncomfortable to wear. A new, smaller, more flexible AFO made of lightweight Teflon has been developed (Camp Healthcare, Inc.). The purpose of this gait analysis was to: 1) identify why the subject experienced anterior knee pain with the traditional "old" style AFO, 2) identify the effectiveness of the "new" ToeOFF AFO, and 3) use electromyography (EMG) to determine if there were muscular compensations as a result of wearing each AFO.

Methodology

The subject in this study was a 50-year-old male (height 73 in, weight 215 lbs). He sustained a back injury in December of 1995, which later required surgical intervention in May of 1996. The surgical procedure was a far lateral laminectomy, which was performed to reduce the pressure on the spinal nerve caused by the prolapsed disc at the L4/L5 level.

The gait evaluation included kinetic, kinematic, and EMG analysis for three conditions: 1) No Brace Condition, 2) Old AFO Condition, and 3) New ToeOFF AFO Condition. EMG data (Therapeutics Unlimited, Iowa City, IA) were collected (960 Hz) for the anterior tibialis, gastrocnemius, peroneals, rectus femoris, and biceps femoris. Resting EMG and maximum voluntary isometric contractions (MVIC) were obtained. A six-camera system (Motion Analysis Inc., Santa Rosa, CA) was used to collect the kinematic data (60 Hz) using the Cleveland Clinic marker set. Kinetic data were collected using a Kistler force plate (Amherst, NY). The data were exported from EVa 6.0 to Orthotrak (Motion Analysis Inc.), so the following variables could be calculated between the conditions: vertical ground reaction forces (VGRF), joint moments, joint ranges of motion (ROM), and integrated EMG.

Results

The uninvolved (left) leg exhibited greater VGRFs than did the involved (right) leg. A foot slap peak was present on right side during the no brace and new brace conditions, while a relatively normal VGRF pattern was exhibited in the old brace condition[2]. A decrease in plantar flexion ROM was noted in both bracing conditions. A premature plantar flexion moment was present during the new brace condition. At the knee, there was a greater flexion ROM with the new brace compared to old brace and without a brace; however a decreased knee flexion moment on the involved side was present during terminal stance. The subject maintained a flexed and externally rotated position of the knee joint throughout the gait cycle. Based on the EMG information gathered during data collected, there were no discernable differences in EMG between conditions.

Discussion

The purpose of an AFO is to compensate for the inability of the tibialis anterior to provide dorsiflexion. Therefore, we would expect more dorsiflexion and less plantar flexion to be apparent in the braced conditions. Our results support this. A decrease in ankle sagittal plane motion was evident. Specifically, there was a lack of dorsiflexion for the no brace condition while the plantar flexion angle was decreased (due to the fixed dorsiflexed position of the ankle resulting from the rigidity of the braces) during both of the braced conditions. In addition to range of motion abnormalities, the net ankle moment in the sagittal plane depicted an absence of a normal dorsiflexion moment and the presence of a premature plantar flexion moment prior to toe-off[1,2]. This premature plantar flexion moment may be due to the lack of anterior tibialis activity to decelerate the foot and prevent foot slap.

At the knee joint, the subject maintained a more flexed position during both of the bracing conditions, although more so with the new brace, throughout the gait cycle. Increased flexion ROM may be beneficial for shock absorption. However, it may reduce the ability of the heel rocker to maintain efficient forward progression[2]. Normally, during loading response, the knee extension moment peaks when the quadriceps are eccentrically controlling knee flexion[2]. In addition, by plantar flexing the ankle, the triceps surae actively unlock the knee from extension at terminal stance/pre-swing, creating a knee flexion moment[2]. In this case, there was a greater extension moment in early stance and a smaller flexion moment in late stance on the involved limb, which may be due to the fixed dorsiflexion position of the right foot.

There was inconclusive evidence to support the hypothesis that the rectus femoris would compensate for tibialis anterior dysfunction. Although EMG of the hip flexors was not measured due to their inaccessibility via surface EMG, some limited kinematic information indicated functional adaptations of the hip flexor musculature during the swing phase of gait. The subject had excessive hip flexion during both bracing conditions, especially with the new brace (reaching 40° of hip flexion) during swing phase. The increased hip external rotation and abduction could be a compensation for the lack of dorsiflexion to provide toe clearance. The researchers did observe some compensatory hip circumduction and external rotation, even though EMG activity did not support this observation.

Conclusions

The following conclusions were drawn from the information provided: 1) anterior knee pain experienced while wearing the old AFO may be attributed to the higher joint compressive forces or higher knee flexion ROM present during the braced condition and the fixed dorsiflexion of the ankle, 2) the ToeOFF AFO was more effective for the subject to achieve a normal gait pattern with some compensatory motions (i.e. flexed knee and circumduction of the hip), but his compliance may be indicative of the improved gait pattern, and 3) EMG was inconclusive for providing evidence to support muscular compensations during gait.

References

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