MECHANICAL EFFICACY OF TENDON TRANSFER OPERATIONS FOR FOOT DROP

INTRODUCTION

There are multiple operations described for foot drop. Posterior tibial tendon transfer through the interosseous membrane (IOM) is popular, but there are concerns that it may not be adequate to obviate continued bracing. The Bridle procedure (BRI) is promising (Rodriguez 1992), but involves 5-7 incisions and a higher potential for complications. The purpose of this study was to compare results of these two operations in cadaveric lower extremities using a dynamic ankle-foot simulator.

MATERIALS AND METHODS

Six fresh-frozen lower extremities without foot-ankle pathology were evaluated. The tibia and fibula were embedded in PMMA and specimen mounted in a previously-validated dynamic ankle-foot simulator, designed to recreate late swing phase and entire stance phase of gait in cadaveric specimens. Input data derived from anatomic, electromyographic, and gait analysis studies were used for ground reaction force profiles, tibial advancement, and application of forces to 6 distinct muscle groups (the gastrocnemius-soleus, posterior tibial, flexor hallucis longus-flexor digitorum longus, anterior tibial, peroneus longus-brevis and extensor hallucis longus-extensor digitorum longus). Axial and fore-aft shear forces were applied with servomotors, with profiles from gait analysis data. Each specimen was pre-tested three times to reduce viscoelastic effect of soft tissue structures.

Three-dimensional motion was determined with a magnetic tracking device (3Space Fastrak system, Polhemus, Colchester, VT), focusing upon metatarsal motion relative to talus and metatarsal motion relative to tibia. Motor control and data acquisition were accomplished using Labview (National Instruments, Austin, TX).

Specimens were tested in 4 conditions: normal, foot drop with extensor muscle forces removed, after IOM, and after BRI. The IOM involved sectioning the posterior tibial tendon at the navicular and rerouting it between the tibia and fibula, deep to extensor retinaculum and through a bone tunnel in the 2nd cuneiform. The BRI involved transferring the posterior tibial tendon between the tibia and fibula, anastomosing to anterior tibial tendon, then to 2nd cuneiform. Additionally, in the BRI procedure, the peroneus longus tendon was sectioned proximally and tenodesis to anterior tibial tendon was performed.

Statistical analysis included repeated measures ANOVA to evaluate the effect of each test condition on foot kinematics, with statistical significance set at p<0.05 level.

RESULTS

Typical metatarsal-tibial sagittal motions in normal, foot drop, BRI and IOM are shown in Figure 1.

Metatarsal-tibial dorsiflexion in late swing phase was 12.6±7.9 degrees in normal and -35.8±4.5 degrees in the foot drop condition. The difference of 48.4±4.2 degrees was significant. There were also differences in foot drop condition in eversion, a difference of -0.3±6.1 degrees, and external rotation, a difference of -9.6±8.7 degrees. The IOM procedure improved dorsiflexion from -35.8±4.5 to 8.2±7.9 degrees, which still differed from normal. It overcorrected eversion by 7.1±3.6 degrees and overcorrected external rotation by 18.7±10.8 degrees. The BRI procedure improved dorsiflexion from -35.8±4.5 to 4.4±14.0 degrees, which differed from normal. It overcorrected eversion by 5.3±3.9 degrees and overcorrected external rotation by 17.8±9.7 degrees.

Metatarsal-tibial maximum dorsiflexion in stance phase was 24.8±6.2 degrees in normal and 17.6±4.0 degrees in the foot drop condition. The IOM procedure improved dorsiflexion from 17.6±4.0 to 27.7±4.5 degrees. The BRI procedure improved dorsiflexion from 17.6±4.0 to 28.1±3.7 degrees.

Typical metatarsal-talus sagittal motion in normal, foot drop, BRI and IOM are shown in Figure 2.

Metatarsal-talus maximum plantarflexion in stance phase averaged 11.0±5.1 degrees in normal, and 12.0±6.2 degrees in the foot drop condition. Both operations significantly reduced plantarflexion in stance phase as maximum plantarflexion was 2.0±2.4 in IOM and 3.4±1.0 in BRI. We were unable to detect any differences between the BRI and IOM operations in terms of immediate mechanical effects.

DISCUSSION

Foot drop operations markedly improved foot dorsiflexion, eversion, and external rotation in late swing phase. These procedures resulted in reduced midfoot motion in plantarflexion. We were unable to detect a significant difference between the operations. These data suggest that the posterior tibial tendon transfer through the interosseous membrane is applicable for most patients with foot drop, as it is relatively simple and effective. The more complex Bridle procedure should be reserved for carefully selected patients with symptomatic foot drop.

REFERENCES