INTRODUCTION

The Achilles tendon possesses the capability to both plantar flex and invert the hindfoot\(^1\). It has been suggested that a medial slide calcaneal osteotomy increases the inverting moment arm of the Achilles tendon. It is theorized that osteotomizing the calcaneus and then medially displacing the posterior calcaneal fragment, and thus the insertion of the Achilles tendon, increases the inverting capability of this tendon. It is therefore hypothesized that a medial slide calcaneal osteotomy (slide osteotomy) decreases the force requirement of the PTT necessary to achieve the calcaneal inversion in the early heel rise portion of the gait cycle. In addition, a new procedure, a medial slide calcaneal osteotomy with distraction (distraction osteotomy), is evaluated. It is also hypothesized that the distraction will decrease the PTT force requirement.

METHODS

Eight intact fresh-frozen cadaver foot-ankle specimens were tested; no attempt was made to create a flatfoot model. Radiographs were taken to screen for existing deformity. Each specimen was prepared by potting the proximal portion of the tibia in epoxy. Flexion angle sensors (MicroStrain, Burlington, VT) were rigidly mounted to the calcaneus to measure dorsiflexion/plantar flexion and inversion/eversion. The specimen was placed in a custom loading apparatus with a tibial orientation consistent with that at the early heel rise portion (40%) of the gait cycle. Stepper motors acting on a plexiglass apparatus with a tibial orientation consistent with that at the early heel rise portion (40%) of the gait cycle. Stepper motors acting on a plexiglass apparatus with a tibial orientation consistent with that at the early heel rise portion (40%) of the gait cycle. Stepper motors acting on a plexiglass apparatus with a tibial orientation consistent with that at the early heel rise portion (40%) of the gait cycle. Stepper motors acting on a plexiglass apparatus with a tibial orientation consistent with that at the early heel rise portion (40%) of the gait cycle. Stepper motors acting on a plexiglass apparatus with a tibial orientation consistent with that at the early heel rise portion (40%) of the gait cycle. Stepper motors acting on a plexiglass apparatus with a tibial orientation consistent with that at the early heel rise portion (40%) of the gait cycle. Stepper motors acting on a plexiglass apparatus with a tibial orientation consistent with that at the early heel rise portion (40%) of the gait cycle. Stepper motors acting on a plexiglass apparatus with a tibial orientation consistent with that at the early heel rise portion (40%) of the gait cycle. Stepper motors acting on a plexiglass apparatus with a tibial orientation consistent with that at the early heel rise portion (40%) of the gait cycle.

Freeze clamps secured the Achilles, posterior tibial (PTT), peroneus brevis (PB) and peroneus longus (PL) tendons to individual stepper motors to simulate muscle activation. Force transducers connected in series with the tendons and stepper motors provided force feedback. Each trial consisted of incremental loading in five steps under a closed-loop feedback position control strategy. The target position was 7° plantar flexion and 5° inversion of the calcaneus, with peroneal co-contraction of 80 N PB and 178 N PL, under GRF components of 50% body weight (Rx = 27 N anterior, Ry = 13 N medial, and Rz = 357 N vertical). Maximum force limits of 1115 N and 445 N for the Achilles tendon and PTT, respectively, were imposed to prevent excessive loads which may lead to rupture. Three trials were collected in the intact foot. A slide osteotomy was performed, with a medial displacement of the posterior calcaneal fragment of 1 cm. Fixation was accomplished using two Steinmann pins and a tension band. Three trials were completed for the slide condition. A distraction osteotomy was then performed, with a 6 mm wood block inserted into the osteotomy site to “distract” the posterior calcaneal fragment. Three trials were completed under this condition. A repeated measures analysis of variance (ANOVA) was used to determine whether there was a statistically significant (p < 0.05) difference in PTT force among the three conditions.

RESULTS

Mean ± standard deviation force requirements for the PTT to achieve 5° calcaneal inversion were 392 ± 45 N for the intact condition, 319 ± 98 N for the slide condition, and 213 ± 140 N for the distraction condition (Figure 1). A statistically significant difference (p=0.008) was found between the intact and distraction conditions.

DISCUSSION

The maximum force limit of 445 N was imposed on the PTT as a preventative measure in order to prevent overloading, as ruptures of this tendon have been found to occur in previous experiments. In some instances, this force limit was reached before attaining the target 5° calcaneal inversion position in the intact condition. For these specimens, the actual PTT force requirement to achieve this position would be expected to be higher than 445 N. This may have affected the statistical analysis, and contributed to the lack of a significant decrease in PTT force in the slide condition. Thus, the conclusion that the slide osteotomy does not significantly reduce the PTT force is a conservative one.

In conclusion, a distraction osteotomy was demonstrated to significantly reduce the force requirement of the PTT in order to achieve the 5° calcaneal inversion position.

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