INTRODUCTION
Split tendon transfer of the tibialis posterior (SPOTT) is commonly performed to correct hindfoot varus in patients with cerebral palsy, stroke, and brain injury. The original SPOTT procedure has been previously shown to alter the action at the subtalar joint but not at the talocrural joint [1]. This procedure involves the longitudinal splitting of the distal tibialis posterior (TP) tendon, routing of the split tendon half posterior to the lateral malleolus, and reattachment to the distal peroneus brevis tendon [2]. Mulier et al. [3] proposed a variation on this procedure in which the split TP tendon was routed through the interosseous membrane to the distal peroneus brevis, and hypothesized that this procedure provided active dorsiflexion while avoiding overcorrection of varus. Medina et al. [4] routed the distal tendon posterior to the tibia but attached to the peroneus brevis, just superior to the lateral malleolus. This procedure reduced the surgical complexity and the need for a lateral dissection on the dorsum of the foot. The goal of the present study was to evaluate the immediate post-operative effects of these variations on the moment arm of TP about the subtalar and talocrural joints and to compare the results with that of the original SPOTT procedure. It was hypothesized that, when compared to the original SPOTT procedure: (1) routing through the interosseous membrane would not result in different postoperative action at the subtalar joint, but would convert the TP into an active dorsiflexor, and (2) attachment to the proximal peroneus brevis would not produce significantly different postoperative results at either joint.

METHODS
The distal tendons of the TP and peroneus longus were identified in six lower leg cadaver specimens (71-88 y; 3 male, 2 female; 1 unknown) and all other soft tissues proximal to a transverse plane 5 cm superior to the malleoli were removed, leaving retinacula and other retaining structures intact. Each foot was rigidly fixed to an aluminum foot plate by two steel rods passing through the calcaneus. An intramedullary rod, secured to the tibia with a cross pin and polymethylmethacrylate, was used to secure the specimen to a testing frame. After the original SPOTT procedure was performed [2], the peroneus longus tendon was harvested and served as the split-transferred tendon for the routing variation procedure. Custom-designed force transducers were sutured in series within the tendon halves and allowed equal balancing of medial and lateral tendon tensions. Proximal to the force transducers, steel cables (0.94 mm dia) simulated the natural split. The common cable was routed through a pulley system that preserved a physiological line of action, and was attached to a cable extension transducer (Celesco PT101) that applied a constant 7 N tension.

Six motion trials were performed for each SPOTT variation with either the subtalar or talocrural joint fixed in anatomical position with two 7.6 cm screws. Motion of the footplate relative to the tibia was measured using an instrumented spatial linkage (ISL). In each trial the foot was held in an anatomically neutral position for two seconds and then manually moved through its subtalar joint range of motion with the talocrural joint locked. Similar trials were performed with motion about the talocrural joint and the subtalar joint locked. Tendon excitations and ISL displacements were recorded at 30 Hz using LabView (National Instruments) software. Joint axes were determined using a non-linear parameter optimization approach and Euler rotations were computed to determine joint angle. TP moment arms were computed as the partial derivative of tendon excursion with respect to joint angle [5].

RESULTS
Split-transferred TP routed through the interosseous membrane was found to have significantly smaller moment arms than the original SPOTT: (1) about the subtalar joint at 10° and 15° inversion (p = 0.001, 0.029) and (2) about the talocrural joint at all angles (all p < 0.001). Attaching TP to a more proximal site resulted in comparable talocrural joint moment arms, and a significantly smaller subtalar joint moment arm only at 15° inversion (p = 0.029) when compared to the original SPOTT.

DISCUSSION
Routing the split tendon half of TP through the interosseous membrane lessened the corrective effect of the split transfer about the subtalar joint when compared to the original SPOTT procedure, especially when the foot was inverted. Intersosseous routing appears to eliminate the inverting action of TP in neutral position and may reduce the risk of overcorrection. TP was not converted into a dorsiflexor by this routing, as was predicted by Mulier et al. [3], but its plantarflexing action was substantially reduced.

Attaching the split tendon half to the proximal peroneus brevis produced results comparable to the original SPOTT about both joints. Following this procedure the TP neither inverted nor everted the foot in an anatomically neutral position. Because this procedure is technically less challenging and avoids lateral dissection of the foot, this surgical variation may be preferable to the original SPOTT.

REFERENCES

ACKNOWLEDGMENTS
The authors wish to thank A. Erdemir, G. Davis, and J. Poreba. Funding was provided by the Whitaker Foundation.

** Shriners Hospital for Children, Erie, PA