SURGICAL INTERVENTION FOR THE CLAWED HALLUX DEFORMITY

Introduction
The term clawed hallux refers to a specific deformity of the great toe. It is clinically defined as the extension of the first metatarsophalangeal joint (MTPJ) combined with flexion of the interphalangeal joint (IPJ). This imbalance is presumed to be a result of a functional “overpull” (a disproportionate load) of one or more of the three extrinsic muscles of the first ray: the peroneus longus (PL), extensor hallucis longus (EHL), and flexor hallucis longus (FHL). This deformity has been reported in several patient populations including those with cerebral palsy, SCI, head injury, and diabetes mellitus. Only one surgical procedure is described for treatment of the clawed hallux and it is blind to the deforming force. The purpose of our research was to assess the effectiveness of different surgical interventions in correcting both the deformity and its mechanical consequences. We examined the angular changes at the MTPJ and IPJ as well as the plantar pressures beneath the first metatarsal and the distal halluc.

Methods
Six fresh-frozen cadaver feet (84 years of age, SD 3.5 years) were obtained for this IRB-approved study. The tibia and fibula of each foot were sectioned 12 cm proximal to the ankle and the extrinsic tendons were dissected free to the superior extensor retinaculum. The feet were randomly selected for either the modified Jones procedure (EHL transfer into the dorsal first metatarsal) or transfer of the FHL into the proximal phalanx. These two procedures address different etiologies.

In the modified Jones procedure, the IPJ of the great toe was exposed through an L-shaped incision on the medial side of the foot. The tendon of the EHL was dissected and cut transversely 1cm proximal to the IPJ joint. The synovial sheath around the EHL was excised. A transverse hole 3 mm was drilled on the inferomedial aspect of the first metatarsal neck and continued along the long axis of the bone until the dorsolateral aspect of the neck. The tendon was passed through the hole and sutured to itself and the periosteum for reinforcement.

For the FHL transfer, a medial midline incision was made over the MTPJ and carried distally to the IPJ. The FHL tendon was exposed under the proximal phalanx. The incision was carried distally to expose the FHL attachment at the distal phalanx. The tendon was cut at its most distal attachment to the distal phalanx. The synovial sheath of the flexor hallucis longus was excised. A 3 mm transverse hole was made through the base of the proximal phalanx. The tendon was passed through the hole and sutured to itself and the periosteum.

The specimens were tested before and after the intervention in a loading frame capable of statically simulating different phases of the gait cycle. The three-dimensional orientation of the bones of interest was measured using the Fastrak electromagnetic motion analysis system; sensors were fastened to carbon fiber rods that were rigidly attached to the talus, 1st metatarsal, proximal phalanx and distal phalanx. The Pedar pressure measurement system was used to measure the plantar pressure; insoles were directly placed beneath the foot prior to testing. Plastic tendon clamps were attached to the free tendons of the extrinsic musculature and the loading protocol developed by Olson et al. was used to simulate overpull of the PL, FHL, and EHL. To determine statistical significance between pre-operative and post-operative conditions, paired t-tests were conducted. Due to small sample differences between surgical procedures were not statistically analyzed.

Results
A significant reduction was found when comparing pre-surgical vs. post-surgical data in the average MTPJ angles (Figure 1) with the overpull of PL (0.59° ± 0.25° vs. 0.17° ± 0.34°, p = 0.0118), FHL (3.11° ± 1.47° vs. 0.22° ± 0.47°, p = 0.0114), and EHL (3.73° ± 1.87° vs. 0.48° ± 1.30°, p = 0.0103). A significant reduction was also found with the average IPJ angles (Figure 2) when the PL (0.22° ± 0.23° vs. 0.13° ± 0.21°, p = 0.0144) and FHL (10.33° ± 6.05° vs. 1.70° ± 2.35°, p = 0.0363) were overpulled. Although the average IPJ angle was reduced with the overpull of the EHL (8.26° ± 6.13° vs. 1.39° ± 2.47°, p = 0.819), this reduction was not found to be statistically significant. Surgery also resulted in an observed reduction of plantar pressure beneath the 1st metatarsal, but only the PL overpull was significant (8.83 N/cm² ± 5.21 N/cm² vs. 4.25 N/cm² ± 5.84 N/cm², p = 0.0384). The only trend with the plantar pressure was a decrease in post-surgical pressure with the FHL overpull, but the difference was not significant.

Discussion
A previous study demonstrated that a disproportionate load applied to the first ray extrinsic muscles creates a clawed hallux. To measure the effectiveness of surgical correction, the modified Jones procedure and the FHL transfer were performed on 6 randomly assigned feet. A reduction in the angular changes at the MTP and IP joints were observed with both interventions as well as a reduction in the plantar pressure beneath the first metatarsal. Both procedures corrected the deformity. Ablation pressure beneath the first metatarsal has been associated with diabetic foot ulcers. Thus optimal plantar pressure reduction is an important surgical outcome. The trend of the means suggests that the FHL transfer reduces first metatarsal pressure more than the modified Jones, but the data suggest that the FHL transfer does not decrease hallux plantar pressure as well as the modified Jones (data not shown). Limitations of this study include the inability of simulating post-surgical healing; we did, however, examine the feet after testing and found no surgical failures with regard to tendon slippage. Another limitation associated with this study is the inability to model a normally dynamic and chronic disorder with the use of static cadaver feet obtained from advanced age specimen.

The peroneus longus has been shown to both stabilize and plantar flex the first metatarsal; it is also the primary muscle involved in increasing the plantar pressure under the first metatarsal. Therefore, future surgical treatment should take this into account. Our future investigations will allow us to quantitatively assess which surgical intervention is best at alleviating the clawed hallux as measured by the reduction of angular changes at the MTP and IP joints as well as significantly reducing plantar pressure under the first metatarsal.

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References
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