A Prospective In Vivo Analysis of First Metatarsophalangeal Joint Mechanics Under Loading Conditions Using Magnetic Resonance Imaging Following Cheilectomy

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Summary:
First MTP joint kinematics were assessed prospectively in surgical patients with hallux rigidus under loaded conditions with novel MRI software. Although patients improve symptomatically following dorsal cheilectomy surgery, dorsiflexion motion was not improved and joint mechanics remained altered.

Abstract:
Background: Although cheilectomy surgery has been shown to provide some pain relief for patients with hallux rigidus, limited data exists regarding the effectiveness of this surgery in re-establishing normal 1st MTP joint kinematics. A recent dynamic gait study has reported only modest improvement in 1st MTP motion following surgery, thus implicating the persistence of altered joint mechanics. The purpose of this study was to prospectively evaluate in vivo joint motion changes using MRI under 1st MTP loaded conditions in patients who received cheilectomy surgery.

Methods: 20 subjects were enrolled between June 2005 and May 2006. Pre- and post-operative data of 10 subjects with hallux rigidus (HR) were compared to a healthy control group of 10 subjects. Using a validated loading harness, all subjects underwent an MRI evaluation at varying angles of 1st MTP dorsiflexion pre and post surgery (>3 months). Image J software was used to derive MRI measurements including the percentage of metatarsal head resection, 1st MTP sagittal motion, instant centers of rotation, and sagittal translations of the proximal phalanx/1st metatarsal. Outcome measures were also assessed using the Foot Function Index (FFI).

Results: The amount of metatarsal head resection was consistent across the HR group: average resection 27.6% ± 4.5%.

Pre-operatively, subjects with HR showed mean peak 1st MTP dorsiflexion values of 34.3º ± 8.7º. Although not significant (p=.07), peak dorsiflexion decreased post-operatively (30.7º ± 9.9º) and remained significantly less than mean peak dorsiflexion values for the control group (62.2º ± 9.2º (p<.001). For the HR group, the pre-operative dorsiflexion range of motion was 23.0º ± 6.8º. There was a significant decrease in postoperative dorsiflexion range of motion (20.2º ± 6.4º: p=0.02).

The instant center of rotation (ICR) was used as an indicator of congruency of joint rotation. Smaller ICRs indicate less displacement of adjacent bony segments. Pre-operatively, the mean ICR was 8.9 ± 1.1 mm, and did not change following cheilectomy (9.2 ± 2.2 mm, p=.67). The values for the HR group were significantly greater than control group values (4.2 ± 1.3 mm; p<.001).

Differences in sagittal translation were calculated for the hallux relative to changes in metatarsal translation. Normal joint motion typically involves greater hallux sagittal plane translation than metatarsal translation. Average change in translation for the control group was 5.1 ± 1.1 mm and
was significantly greater than the HR group, both pre- 1.6 ± 1.1 mm (p<.001) and post-operatively 1.7 ± 1.1 mm (p<.0001).

A significant decrease in FFI scores was found in the HR group, indicating improvement. Average preoperative score was 46.9 vs. 32.4 postoperatively (p=.001).

Discussion/Conclusions: Joint mechanics are significantly altered in patients with hallux rigidus. Although cheilectomy resulted in favorable outcomes as measured by FFI scores, surgery did not re-establish normal 1st MTP joint kinematics. Long term follow up of these patients will determine if altered kinematics lead to progressive arthritis over time.