Role of Plantar Plate and Surgical Reconstruction Techniques on Static Stability of Lesser Metatarsophalangeal Joints: A Biomechanical Study

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Introduction
Instability of the lesser metatarsophalangeal joints (MTPJ) is a common clinical problem that is thought to be caused by partial or complete rupture of the static restraints of the MTPJ; the plantar plate and/or the collateral ligaments. All of the surgical treatments described have shown mixed clinical results. In an effort to better understand the role of the static restraints and current surgical reconstruction techniques on lesser MTPJ instability we conducted this biomechanical study.

Methods
Fresh-frozen and thawed human cadaveric foot specimens were mounted to a rigid plate supporting the forefoot; the 2nd, 3rd, and 4th toes were individually displaced in subluxation, dorsiflexion, and plantar flexion using an Instron test frame in position control. Each specimen was pre-cycled 10 times at 80% of full physiological range of motion and then load data were recorded at 100% of full physiological motion for each motion axis in intact, disrupted, and repaired (Weil Osteotomy or Tendon Transfer) test conditions. Specimens were displaced with a 25 mm moment arm measured distally from the center of rotation of the lesser metatarsophalangeal joint for dorsiflexion, and plantar flexion. For subluxation displacements, the clinical “drawer test” was simulated by displacing the toes as proximally as possible while controlling rotation. Data were normalized to the intact condition of each toe.

Results
Results to date indicate that both the Weil Osteotomy and the Tendon Transfer do not fully restore the stability of the toe back to the intact values. In general, the Weil Osteotomy was not as stable as the Tendon Transfer. Subluxation results indicated that disruption of the plantar plate decrease stability to 90% of intact. An osteotomy further decreased this stability to 45% of the intact while a tendon transfer decreased stability to 80% of the intact. Dorsiflexion results indicated that disruption of the plantar plate decreased the stability to roughly 70% of intact. An osteotomy further reduced this stability to 50% of the intact while a tendon transfer improved stability to 80% of the intact. Plantar flexion results indicated that disruption of the plantar plate decreased the stability to roughly 80% of intact. An osteotomy further reduced this stability to 74% of the intact while a tendon transfer improved stability to nearly 90% of the intact.
Conclusion
Disruption of the plantar plate and the collateral ligaments of the lesser MTP joints led to significant instability. Distal metatarsal osteotomy further destabilizes the joint while a tendon transfer of the long flexor tendon to the extensor hood restores almost normal static restraints against translation, dorsiflexion and plantarflexion.