Effect of a Supramalleolar Osteotomy in a Novel Asymmetric Ankle Arthritis Model

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Introduction:
Asymmetric ankle arthritis remains a complex clinical problem for foot and ankle surgeons. While good outcomes have been reported with realignment surgery, results are not uniform. Biomechanical explanations for the effects of realignment surgery have yet to be elucidated. Some studies have even shown paradoxical results. The purpose of this pilot study is to investigate the effects of a supramalleolar realignment osteotomy (SMO) on tibiotalar joint pressures and contact areas in a novel asymmetric arthritis model to better mimic the in-vivo scenario.

Methods:
Twelve paired cadaveric lower leg specimens were axially loaded to simulate a single leg stance up to 700N. Baseline intra-articular pressure and contact area measurements were obtained via pressure sensors in the native specimens. A varus (right-sided specimens) or valgus (left-sided specimens) deformity model simulating stage 4 asymmetric arthritis was designed for all specimens via a limited ligamentous release and eccentric removal of cartilage. Specimens were reloaded to 700N and intra-articular pressure and contact area measurements were reassessed. A valgus (right-sided specimens) or varus (left-sided specimens) supramalleolar osteotomy was then made, and realignment was created with 5-, 10-, and 15-degree opening-wedges. The specimens were then reloaded and retested with each wedge. The above protocol was repeated after a fibular osteotomy to assess the effects of an intact fibula. A two-way ANOVA was performed for all parameters to assess differences between the groups.

Results:
Ankles in the varus arthritis model showed a mean shift in the center of pressure (COP) of 4.4±1.9mm in a posterior and medial direction. In the varus arthritis specimens, an isolated valgus supramalleolar osteotomy using 5-,10-, and 15-degree wedges caused the COP to shift in an anterior and lateral direction, with a mean shift of 5.0±3.0, 4.7±2.4, and 4.5±1.3mm, respectively. When valgus osteotomy was combined with fibular osteotomy, the COP shift was 6.0±2.5, 6.4±2.2, and 6.2±2.4mm in an anterior and lateral direction. Ankles in the valgus arthritis model showed a mean COP shift of 5.4±2.0mm in an anterior and lateral direction. A isolated varus supramalleolar osteotomy using 5-,10-, and 15-degree wedges caused the COP to shift in a posteromedial direction, with a mean shift of 3.4±2.1, 3.5±2.2, and 3.8±2.1mm, respectively. When varus osteotomy was combined with fibular osteotomy, mean COP shifts were 3.0±2.2, 3.0±2.1, and 3.9±1.4mm in a posteromedial direction. A two-way ANOVA showed no significant difference between corrections of 5-, 10-, and 15-degrees in both the varus and valgus models. However, compared to an intact fibula, a fibular osteotomy resulted in a significant difference in
the COP shift from a posteromedial to an anterolateral direction in the varus model (p=0.018) and from an anterolateral to a posteromedial direction in the valgus model (p=0.008).

**Discussion:**
The creation of asymmetric arthritis in cadaveric ankle specimens caused a shift in the intra-articular COP. In a varus model, the COP shifted in a posteromedial direction; in a valgus model, the COP shifted in an anterolateral direction. A supramalleolar osteotomy helped to normalize this COP shift, more so when combined with fibular osteotomy.

**Significance:**
In patients with asymmetric ankle arthritis, ankle realignment surgery with a supramalleolar osteotomy (SMO) has shown promising, though variable, clinical results. The effects of a SMO remain poorly understood from a biomechanical standpoint, as prior studies have failed to adequately recreate an in-vitro model of asymmetric ankle arthritis. In this study, we employ a novel cadaveric model of asymmetric ankle arthritis in order to more closely reapproximate the in-vivo scenario, and better elucidate the effect of a SMO, with and without concomitant fibular osteotomy, on tibiotalar joint contact pressures. A supramalleolar osteotomy helped to normalize the COP shift that occurs in asymmetric arthritis, more so when combined with fibular osteotomy.

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