Compensatory Gait Strategies in Medial Ankle Osteoarthritis: The Modifying Effect of Concurrent Knee Pathology

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Introduction: Medial ankle osteoarthritis (OA) represents an intermediate stage of ankle degeneration where compensatory mechanisms remain partially preserved. While ankle OA necessitates adaptations throughout the lower extremity kinetic chain, specific compensation strategies and their alteration by concurrent joint pathology remain unclear. This study aimed to 1) characterize multi-joint compensatory patterns in medial ankle OA, and 2) determine how concurrent knee OA modifies these ankle-driven adaptations.
Methods: Forty-two patients with medial ankle OA (Takakura stage 2-3B) were divided into isolated ankle OA (Group 1, n=22) and ankle OA with concurrent knee OA (Group 2, n=20). Forty-four age-matched healthy controls were included. The group demographics showed no significant differences in age (Group 1, 66.9±11.2 years; Group 2, 63.2±8.7 years; Control, 65.0±2.8 years; p=0.228) or sex distribution (Group 1, 10 male/12 female; Group 2, 6 male/14 female; Control, 10 male/34 female; p=0.477). Three-dimensional gait analysis was performed at self-selected speed. Spatiotemporal parameters, multi-planar kinematics, and joint moments were analyzed using Statistical Parametric Mapping (SPM). Each patient group was compared to controls to identify distinct compensatory patterns.
Results: Both groups demonstrated significantly increased ankle varus moments (Group 1: 0.24±0.16 vs 0.09±0.07 Nm/kg; Group 2: 0.21±0.08 vs 0.09±0.07 Nm/kg; p<0.001) compared to controls. In response to ankle pathology, Group 1 developed comprehensive proximal compensations including pelvis internal rotation, hip external rotation, and knee internal rotation throughout stance (SPM, p<0.001), with increased step width (14.3±3.4 vs 9.4±2.7 cm). Remarkably, hip external rotation moment decreased 31% despite maintained kinematics. Group 2 showed restricted proximal adaptations with only partial hip compensation and no significant pelvis or knee contributions, but demonstrated greater distal compensations at the hindfoot level.
Discussion: Medial ankle OA triggers sophisticated multi-joint compensatory strategies that extend well beyond the ankle joint. When knee OA is absent, patients successfully employ proximal-driven adaptations, achieving efficient mechanical unloading. However, concurrent knee OA fundamentally disrupts these compensatory options, forcing reliance on distal mechanisms. These findings emphasize that ankle surgeons must assess the entire lower extremity when treating medial ankle OA, as the presence of knee pathology dramatically alters available compensation strategies and may impact treatment outcomes. Preservation of proximal compensation capacity should be considered in treatment planning.

SIGNIFICANCE/CLINICAL RELEVANCE: This study demonstrates that isolated medial ankle OA patients can successfully employ proximal compensatory strategies to achieve mechanical unloading, while concurrent knee OA fundamentally disrupts these adaptive mechanisms and forces reliance on less efficient distal compensations. These findings provide foot and ankle surgeons with evidence-based insights for developing targeted rehabilitation protocols and surgical timing decisions, emphasizing the need for comprehensive lower extremity assessment rather than isolated ankle-focused treatment approaches.

IMAGES AND TABLES:

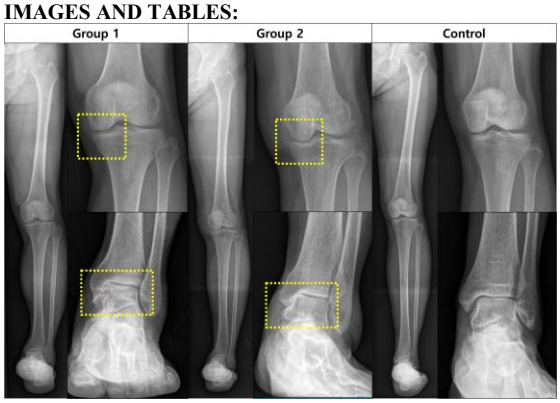

Figure 1. Representative radiographs of included patients

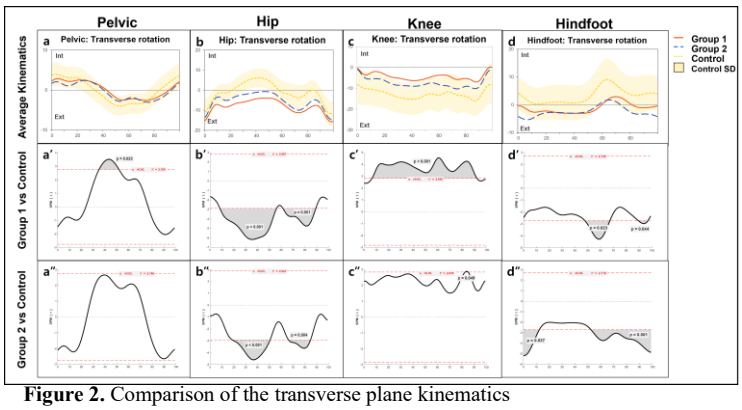

Figure 2. Comparison of the transverse plane kinematics

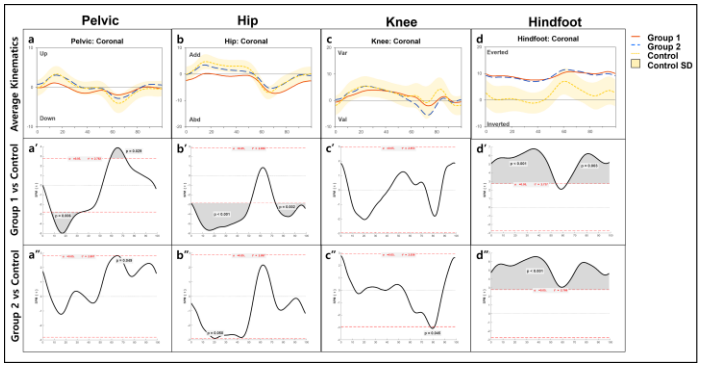

Figure 3. Comparison of the coronal plane kinematics