Lower Limb Alignment Compensation of Knee Deformity Occurs Through the Subtalar Joint

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Introduction:
Lower extremity malalignment, particularly at the knee joint, will affect hindfoot orientation, requiring compensation for proper gait. Three locations where compensation potentially could occur include the distal tibia, ankle joint, and subtalar joint. We hypothesized that compensation at each level of the distal tibia, ankle joint, and subtalar joint correlates with the overall malalignment of the hindfoot and the majority of the compensation occurred at the subtalar joint.

Methods:
378 TKAs in 304 patients were evaluated.Standing full-leg-length AP and Saltzman hindfoot alignment view radiographs were used to determine the mechanical axis angle, degree of hindfoot malalignment (Figure 1), anatomic lateral distal tibial angle (Figure 2), and ankle joint line convergence angle (Figure 3). The relationship between knee deformity, as well as hindfoot deformity, and the aLDTA, ankle JLCA, and subtalar joint (STJ) were assessed for correlation. Intraclass correlation coefficients were used to evaluate intra- and interobserver reliability. IRB approval was attained.

Results:
The mechanical axis angle correlated with aLDTA, ankle JLCA, and the STJ in the entire cohort and in a sub-group of patients with ≥10° knee deformity. The hindfoot angle correlated with aLDTA, ankle JLCA, and STJ in the entire cohort. The difference in aLDTA, ankle JLCA, and STJ between knees with varus and valgus deformity were significant in the ≥10° knee deformity cohort. The difference in aLDTA, ankle JLCA, and STJ between hindfeet with varus and valgus deformity were significant in the entire cohort. Intra- and interobserver reliability analysis showed excellent reliability in all measurements.

Discussion:
This study found a moderate statistically significant positive correlation between the hindfoot angle and the aLDTA, as well as with the ankle JLCA. These relationships indicate that a small amount of hindfoot compensation occurs at both the distal tibia and at the ankle joint. Finally, this study shows that in patients with hindfoot malalignment, due to knee deformity, there exists a strong statistically significant positive correlation between the hindfoot angle and the STJ. This confirms the hypothesis that the majority of compensation within the hindfoot, in response to knee deformity, occurs through the STJ while the aLDTA and ankle JLCA have a minimal role in the overall compensatory ability of the hindfoot. These findings have direct implications for treating patients with both knee and foot/ankle problems. One concern is that in patients undergoing total knee arthroplasty (TKA), who also present with a stiff STJ, may have subsequent, post-TKA foot/ankle pain or disability due to the inability of the STJ to reorient itself after knee realignment. This finding suggested that patients undergoing TKA whom also have a stiff STJ should be counseled that their hindfoot symptoms may worsen following TKA. Additionally, one should consider recommending that patients (with severe knee arthritis) who present with foot/ankle pain caused by impingement or tibial posterior tendonitis resulting from the compensatory mechanism of the STJ, secondary to knee deformity, should consider undergoing total knee arthroplasty prior to foot surgery.

Although radiographs were taken in orthogonal planes under standard protocols, the rotational effect of the lower extremity was not taken into account when determining malalignment. Additionally, bone deformity in the hindfoot was not studied because the particular age group used in this study (mid-30s to 90s) was unlikely to have congenital deformities of the hindfoot as any deformity would have presented earlier in life and would not have been included in this study. Finally, a dynamic kinematic evaluation of the subjects would provide a higher degree of accuracy compared to the static measurement employed in this study.

This study demonstrates that in patients with hindfoot malalignment, due to knee deformity, there exists a significant correlation between the hindfoot angle and the STJ. The majority of compensation within the hindfoot occurs through STJ while aLDTA and ankle JLCA have a minimal role in the overall compensatory ability of the hindfoot.

Significance:
Lower extremity malalignment, particularly at the knee joint, will affect hindfoot orientation. This study demonstrates that in patients with hindfoot malalignment, due to knee deformity, there exists a significant correlation between the hindfoot angle and the STJ with the majority of compensation within the hindfoot occurring through the STJ.

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