Radiographic Measurement of Medial Distal Tibial Angle, Part II: Influence of Ankle Position (Rotation, Dorsiflexion/Plantarflexion) and Radiograph Technique on Obtained Results

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Summary:
The hindfoot alignment view (HAV) is considered the gold standard for assessing the axis from hindfoot to tibia. However, it is unclear whether medial distal tibial angle (MDTA) can be measured reliably using the HAV. Seven fresh-frozen foot/ankle specimens were used in this study. Digital reconstructed radiographs (DRRs) were extracted to address the influence of foot/ankle position and radiograph technique on MDTA.

Introduction:
The hindfoot alignment view (HAV) is considered the gold standard for assessing the axis from hindfoot to tibia. However, it is unclear whether medial distal tibial angle (MDTA) can be measured reliably using the HAV. In our previous clinical study, significant differences in MDTA were found between measurements with the HAV and anteroposterior ankle radiographs. The MDTA was not correlated to age, gender, or ankle geometry (anterior distal tibial angle). Therefore, in this study we assessed the influence of (1) foot/ankle position regarding rotation and dorsiflexion/plantar flexion and (2) radiograph technique (angle from the horizontal) on MDTA measurements.

Methods:
Seven fresh-frozen foot/ankle specimens (all male, mean age 65.0 ± 16.5 years; range, 52 to 89 years; 3 right, 4 left, two specimens paired) were used in this study. A CT scan was performed on all specimens in neutral position and in dorsiflexion (up to 15°) and plantar flexion (up to 25°) in 5° increments using a custom radiolucent acrylic fixation device (Figure 1A). CT scan data were segmented to create 3D foot/ankle model and digital reconstructed radiographs (DRRs) were extracted using Amira®. The following parameters were altered during extraction of DRRs: axial rotation of the foot (from 30° external to 30° internal rotation in 5° increments) and angle from the horizontal (from 0° to 25° in 5° increments). In the first two specimens, the sensitivity of increment steps was performed to reduce the number of measurements. All measurements in the first two specimens were performed by two observers at different training levels to assess the interobserver reliability. The evaluation of 150 radiographs was repeated 6 weeks after the initial read to assess intraobserver reliability. In specimens 6 and 7 a radiological control study was performed to assess the reliability of the DRR extraction method. Specifically, the specimens were radiographed at fixed increments. An ANOVA-test was used for comparison of continuous data. The inter- and intraobserver reliability was quantified by the interclass correlation coefficient (ICC). The level of significance for all tests was set at p ≤ 0.05.

Results:
MDTA measurements were significantly correlated between conventional radiographs and DRRs at a given view (r = 0.914, p < 0.001). The ICC for intra- and interobserver reliability was excellent: 0.912 (95%CI, 0.881 to 0.952) and 0.882 (95%CI, 0.792 to 0.916), respectively. Axial foot/ankle rotation significantly altered MDTA measurements obtained using the HAV (P < 0.001), but not AP radiographs (P = 0.736) (Figure 1B). Dorsiflexion and plantarflexion were statistically different between MDTA measurements using AP radiographs (P = 0.003), but not HAV (P = 0.440) (Figure 1C). Also the radiograph technique (angle from the horizontal) had a statistically significant effect on MDTA measurements (P = 0.027) (Figure 1D) with decreasing MDTA at increasing angle from the horizontal (R Square = 0.334, P = 0.001).
Conclusions:
Radiograph technique has a significant influence on MDTA measurements, which explains why MDTA differed between AP and HAV radiographs. As HAV is more sensitive regarding the foot/ankle rotation, MDTA should be measured using AP radiographs. However, precise positioning of ankle (rotation, dorsiflexion/plantar flexion) could avoid bias in MDTA measurements between views.