Automated Posterior Tibial Slope Measurement Using Lateral Knee Radiographs: A Novel Landmark-Based Approach Using Deep Learning

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INTRODUCTION:

A single universally accepted protocol for measuring the posterior tibial slope (PTS) does not exist. This limits the clinical translation of the literature regarding cut-off values for surgical decision making and risk stratification.

The purpose of this study was to validate an online computer vision model based on anatomical landmarks for PTS determination using uncalibrated lateral knee radiographs. The hypothesis was that this model would enable clinicians to calculate PTS with similar accuracy to manual measurement on the same images.

METHODS:

A total of 10,007 lateral knee radiographs collected between January 2009 and December 2019 were utilized. The dataset comprised 9,277 (93%) training, 500 (5%) validation, and 230 (2%) test radiographs. After defining “A” as the distance from the tibial joint line to the proximal aspect of the tibial tuberosity, two *Landmark-based* methods for determining the tibial shaft axis were developed based on lines connecting the tibia midpoints at distances: 1) 2A and 3A (Short Method), and 2) 2A and 4A (Long Method). The PTS was then calculated using each tibial shaft axis. Model performance was evaluated against orthopedic specialists' measurements using inter-observer and intra-observer intraclass correlation coefficients (ICCs). Model performance on shortened images, subcategorized into normal, osteoarthritic, and implant-embedded knees, was also assessed, along with time efficiency comparisons.

RESULTS: The overall inter-observer ICC was 0.91 (Short Method) and 0.92 (Long Method) against manual measurement. ICCs for normal, osteoarthritic, and implant-embedded radiographs were 0.84, 0.90, 0.97 for the Short Method and 0.88, 0.91, and 0.97 for the Long Method, respectively. The model measurement time averaged 2.5±0.7 seconds, compared to 26.1±1.9 seconds for manual measurement ($P<0.001$).

DISCUSSION AND CONCLUSION:

A novel, time efficient, deep learning model for measuring PTS demonstrated excellent accuracy and consistency across various lateral knee radiographs. If externally validated, this model may enable a pathway for direct clinical translation of research findings by providing a standardized measurement tool.