

AI-Guided Femoral Stem Sizing Improves Accuracy and Reduces Risk in Total Hip Arthroplasty

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INTRODUCTION: Accurate femoral stem sizing in total hip arthroplasty (THA) is essential to minimize complications such as subsidence, loosening, and periprosthetic fracture. While demographic data have been shown to outperform manual templating, such methods often overlook patient-specific anatomical variation. To date, only one study has reported a model for predicting stem size using demographics alone; a task complicated by morphological variability across implant designs. This study evaluates a novel artificial intelligence (AI) approach that integrates preoperative imaging with demographic data to improve stem size prediction and explore associations with postoperative complications.

METHODS: A multimodal AI algorithm was trained on an independent development dataset comprising demographic variables, preoperative radiographs, and implanted femoral stem sizes, with consideration for cross-implant generalizability. The model was retrospectively evaluated on a hold-out series of 2,085 THA cases from a tertiary academic referral center. Predictive performance and associations with complications, such as fracture or loosening, were assessed.

RESULTS: The integration of preoperative imaging significantly improved prediction accuracy compared to demographic data alone ($p < 0.0001$), improving size prediction by at least one size in 25.9% of cases. In the validation cohort, the AI model predicted femoral stem size within an average of 0.787 sizes of the implanted stem (median: 1; range: 0–4); 78.6% were within 1 size, 94.8% within 2 sizes, and 99.8% within 3 sizes. In contrast, the demographic-only model had a mean absolute error of 1.240 sizes. A greater positive deviation from the predicted size was associated with a significantly increased risk of complication (OR: 1.773; $p < 0.0001$).

DISCUSSION AND CONCLUSION: This is the first study to evaluate a multimodal AI model that combines imaging and demographic data for femoral stem sizing in THA. The addition of imaging improved prediction accuracy while preserving the strengths of demographic-based approaches. Importantly, deviation from the model's predicted size was strongly associated with postoperative complications, suggesting that AI-guided sizing may serve as both a preoperative planning tool and a risk stratification aid in THA.