TITLE: Is it Feasible to Develop a Supervised Learning Algorithm Incorporating Spinopelvic Mobility To Predict Impingement In Patients Undergoing Total Hip Arthroplasty? A Proof-of-Concept Study.

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ABSTRACT: This study is a proof-of-concept. Obtain images of spinopelvic mobility to predict impingement and planning parameters. Using 5-fold cross-validation and repeating experiments with 10 randomly selected seeds, the Light Gradient Boosting Machine (LGBM) emerged as the preferred model demonstrating both accurate prediction and robustness. LGBM achieved an accuracy of 70.2% with the 9-characteristic dataset. When provided with impingement data as additional input, LGBM and Linear Regression (LR) estimated impingement direction in a Total Hip Arthroplasty. Some studies have sought to predict instability and define a personalized safe zone for component placement, there is a notable gap in research utilizing Artificial Intelligence (AI) for predicting impingement. To this end, our study poses the following questions: 1) Is it feasible to devise an Artificial Intelligence algorithm tailored to the individual spinopelvic mechanics and patient phenotype to predict impingement? 2) How precise is the proposed algorithm in its predictions? and 3) can the algorithm’s accuracy be augmented by integrating imaging data?

METHODS: In this international, multicenter study across two centres, we evaluated the feasibility and accuracy of AI algorithms predicting THA impingement using patient phenotypes and spinopelvic mechanics. Our cohort consisted of adults undergoing primary robotic-armed assisted THA. Standard pre-operative imaging included a CT, weight-bearing AP pelvis radiographs, and lateral spine radiographs in the standing and relaxed-seated position. Impingement during specific flexion and extension stances were identified using the virtual Range of Motion (ROM) tool of the robotic software. Our initial sample, 157 participants (aged 32-88 years) were included in our primary analysis. The primary AI model, the Light Gradient Boosting Machine (LGBM), used tabular data to predict impingement presence, direction (flexion or extension), and type. A secondary model integrating tabular data with plain AP pelvis X-rays was evaluated to assess for any potential enhancement in prediction accuracy.

RESULTS SECTION:
Focusing on the feasibility of a predictive algorithm, we identified nine predictors from an analysis of baseline spinopelvic characteristics and surgical planning parameters. Using 5-fold cross-validation and repeating experiments with 10 randomly selected seeds, the Light Gradient Boosting Machine (LGBM) emerged as the preferred model demonstrating both accurate prediction and robustness. LGBM achieved an accuracy of 70.2% with the 9-characteristic dataset. When provided with impingement data as additional input, LGBM and Linear Regression (LR) estimated impingement direction in a Total Hip Arthroplasty. Some studies have sought to predict instability and define a personalized safe zone for component placement, there is a notable gap in research utilizing Artificial Intelligence (AI) for predicting impingement. To this end, our study poses the following questions: 1) Is it feasible to devise an Artificial Intelligence algorithm tailored to the individual spinopelvic mechanics and patient phenotype to predict impingement? 2) How precise is the proposed algorithm in its predictions? and 3) can the algorithm’s accuracy be augmented by integrating imaging data?

SIGNIFICANCE/CLINICAL RELEVANCE: For arthroplasty surgeons without access to CT-based navigation or robotic systems offering virtual Range of Motion, a refined AI algorithm predicting impingement based on individual patient phenotypes could be instrumental in guiding pre-operative planning and preparing surgeons for potential intraoperative challenges. In our proof-of-concept study, we successfully showcased the feasibility of an algorithm to predict impingement, exhibiting good accuracy in predicting impingement and type (bone-on-bone, implant-on-implant, implant-on-bone) and excellent accuracy in determining its direction.