# AI-Based Prediction of Pelvic Tilt Change in THA: Validation and Pilot Application Using Paired Radiographs

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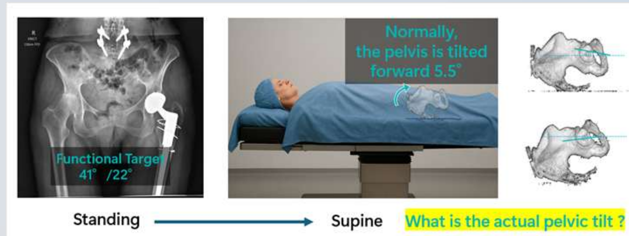
## Introduction

Accurate component orientation in total hip arthroplasty (THA) is essential for minimizing complications such as dislocation, edge-loading, and implant wear [1]. Functional implant positioning requires an understanding of how pelvic tilt (PT) changes between standing and supine postures [2]. While the average anterior tilt from standing to supine is approximately 5–6°, individual variation exceeds 40°, making prediction difficult [3]. CT-based navigation and robotics provide high precision but are costly and require preoperative CT [4]. Alternative methods such as augmented reality (AR)–based systems that define the anterior pelvic plane (APP) by skin-pointing, inertial sensors, or intraoperative fluoroscopy have been proposed, but each carries limitations such as operator dependency, added complexity, or radiation exposure [5,6].

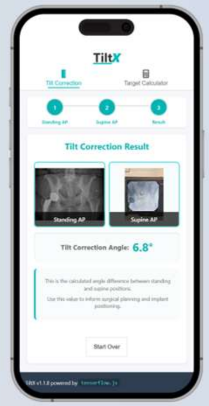
We aimed to validate an AI-based model that predicts posture-related pelvic tilt change from standard radiographs and to assess its feasibility through a pilot clinical application during preoperative planning in THA.

## Materials and Methods

A deep learning model was trained on 300 paired standing and supine AP pelvic radiographs in PNG format. Bounding boxes were manually annotated by a single non-clinical operator based on visual landmarks used in the application. A YOLO-based object detection model was trained using PyTorch. The model output was processed by a geometric algorithm to estimate the change in pelvic tilt (ΔPT) based on the spatial configuration of pelvic structures. The model was converted to TensorFlow.js for mobile deployment without quantization to preserve precision (Figure 1).

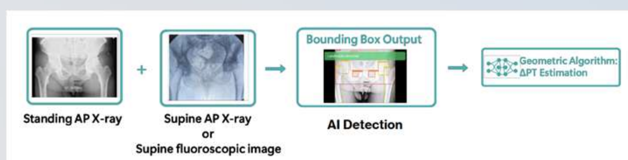



Validation was conducted in two phases:




Initial validation (n = 21): CT-based 3D pelvic reconstructions were used to calculate reference ΔPT, which was compared to AI-predicted ΔPT using paired standing and supine X-rays.

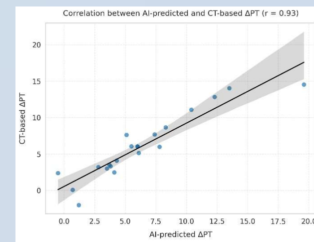
Pilot clinical application (n = 8): Following anesthesia induction, a single supine fluoroscopic image was acquired. The AI model estimated ΔPT using the preoperative standing radiograph and intraoperative supine fluoroscopy. Predicted ΔPT values were used to adjust target cup angles in a portable inertial navigation system. Postoperative CT scans were used to assess the accuracy of final implant positioning.




## Results

The mean reference ΔPT from CT was 6.00° ± 2.1°, and the AI model predicted 6.30° ± 2.4°, with a correlation coefficient of r = 0.931 ($p < 0.001$)(Figure 2). In the pilot clinical application, one case failed detection. Among the remaining seven patients, the mean predicted ΔPT was 6.39°. Final implant placement errors were 1.1° for inclination and 1.0° for anteversion compared to the intraoperatively achieved implant angles using the navigation system (Figure 2).

| Approach | Measured ΔPT |
|---|---|
| CT-based | 6.00°± 2.1° |
| AI-predicted | 6.30°± 2.4° |




## Conclusion

This AI-based prediction model demonstrated feasibility for CT-free, posture-aware preoperative planning in THA. Using only standard radiographs, it enabled estimation of functional pelvic orientation. The predicted values showed high correlation with CT-based measurements. Further software refinement and larger-scale validation are required to support broader clinical application.

## Reference

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