Three-Dimensional Pelvis Kinematics During Operative Motions of DA-THA on a Hana Table

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Introduction

- Pelvis orientation during direct anterior total hip arthroplasty (DA-THA) influences acetabular cup positioning (Figure 1), which affects post-operative outcomes including hip stability and dislocation risk [1,2]
- Acetabular reaming and impaction are performed under various amounts of traction, hip extension, and external rotation, based on the surgeon's discretion
- Few studies have reported dynamic pelvic orientation in multiple planes throughout the DA-THA procedure [3,4]

Objective: Quantify three-dimensional pelvis kinematics during DA-THA facilitated by a Hana table

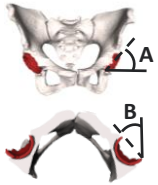

Fig. 1 Acetabular inclination (A) and anteversion (B).

Methods

- 5 torso-to-toe specimens (10 hips) were tested (74.6±13 years; 18.8±4.1 BMI)
- Specimens were positioned supine on a Hana table and optical markers were rigidly attached to the pelvis and table to record 3D kinematics (Optotrak Certus, NDI Inc) (Figure 2)
- Data was collected during the following surgical steps:
  - Movement 1: external rotation
  - Movement 2: hyperextension and adduction
  - Femur broaching
  - Movement 3: flexion and abduction
  - Movement 4: reduction of the implanted hip (distraction and internal rotation)
- Hips were implanted with CORAIL stems and PINNACLE cups (DePuy Synthes, Inc) by the same surgeon with the use of a C-arm
- After testing, fiducials were placed in the pelvis and digitized within the motion capture system. Bones were denuded and optically scanned to register the bones and implants to the motion capture data
- Subject-specific anatomic coordinate systems were established using CT-based segmentations for kinematic calculations
- 3 degree of freedom (DOF) rotational pelvis kinematics were quantified relative to the Hana table: pelvic flexion (PF) in the sagittal plane, lateral tilt (LT) in the coronal plane, and axial rotation (AR) in the axial plane

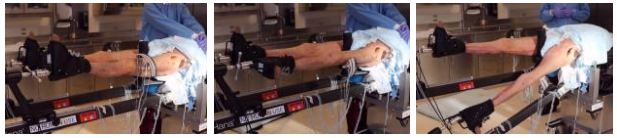

Figure 2. Surgical positions of interest from left to right including the initial supine position, externally rotated (Movement 1), and hyperextended and adducted (Movement 2)

Results

- Average PF in the initial supine pose was 5.9°±5.7°, with minimal LT and AR (Figure 3)
- LT and AR both increased after external rotation (LT: 1.0°±0.5°; AR: 2.9°±1.7°), hyperextension and adduction (LT: 2.3°±1.1°; AR: 3.7°±2.9°) and femoral broaching (LT: 4.2°±3.1°; AR: 5.9°±2.9°) (Figure 4)
- LT and AR magnitudes decreased at the end of Movement 3 compared to the beginning of the movement (Figure 5)
- Maximum LT occurred during reduction, which was also accompanied by high AR angles (LT: 6.3°±3.7°; AR: 4.8°±1.9°) (Figure 4)

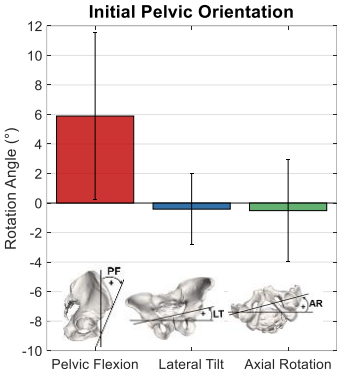

Figure 3. Average (±SD) initial pelvic orientation

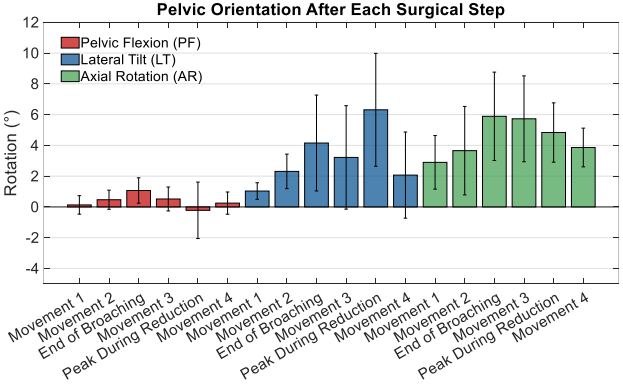

Figure 4. Average (±SD) pelvic orientation after each movement, relative to the initial pelvic orientation in the supine position

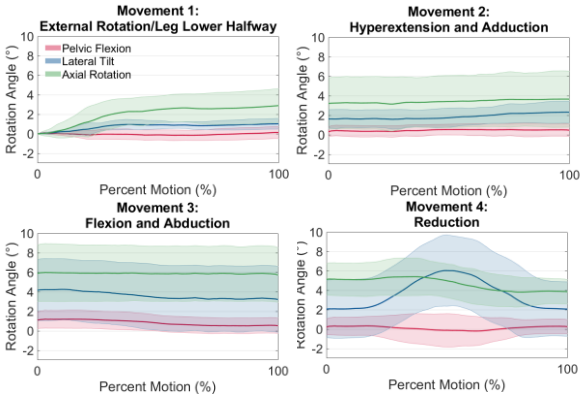

Figure 5. Average (±SD) pelvic orientation from 0 to 100% of each operative leg movement

Discussion

- There is limited data on intraoperative pelvic positioning during surgical motions essential to the DA-THA procedure on a traction table and the associated impact on implant positionings
- This study quantified pelvic orientation throughout the procedure, providing information for surgical decision making
- Minimal pelvic flexion was observed during the surgical movements, but the pelvis experienced average lateral tilt towards the operative hip by 2.3±1.1° (max: 4.2°) and rotated axially 3.7°±2.9° (max: 10.4°) relative to the initial position after Movement 2. These rotations are small relative to the hypothetical cup "safe zone", but may be clinically relevant if the surgeon assesses cup position in this pose
- Future work will analyze pelvic motion during acetabular reaming and cup impaction

References

[1] Parilla, *J Arthroplasty,* (2019) [2] Yang, *Orthop Surg* (2019) [3] Roettges, *J Arthroplasty,* (2018) [4] Mouri, *Arthroplasty Today,* (2023).
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