A Novel Intrapelvic THA Technique Accurately Positions Components and Maintains Tissue Tension

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INTRODUCTION: During total hip arthroplasty (THA), appropriate management of capsular soft tissue is believed to be crucial to avoid instability following impingement, a common reason for failure.[1] However, our understanding of the biomechanical contribution of the capsule to stability after THA is limited by the inherent need of dissecting the capsule for component implantation in cadaveric experiments. Prior research attempted to address this limitation by developing intrapelvic THA implantation models utilizing custom implant constructs,[2,3] but these constructs utilized custom components that do not capture the biomechanics of commercially available THA components. Thus, our goal was to develop a capsule-sparing cadaveric THA implantation model for experimental testing using conventional, off-the-shelf implants. We hypothesized that implants can accurately be placed through an intrapelvic approach and that relative contributions of the capsular ligaments will not differ from standard THA.

METHODS: Four bilateral male cadaveric specimens (66±6 years) underwent THA: one side of each pelvis was randomly assigned to receive a standard direct anterior approach (DAA) THA and the contralateral side using the intrapelvic technique. The specimens were CT-scanned before and after implantation to verify the position of the components. The DAA side was performed first by a fellowship trained orthopedic surgeon using standard instruments and components (48-mm Trident II shell and Size 3 Accolade C stem, Stryker). The intrapelvic side was planned based on the DAA side by mirroring (DesignX, Geomagic) the component positions from the DAA side to the intrapelvic side (**Fig 1A**). To achieve the planned component position, we utilized specimen-specific 3D-printed guides to core the pelvis, prepare the femur, and implant the components. A first coring guide attached to the medial (i.e., inner) wall of the pelvis at the pubic, iliac, and ischial bones, to create a 52-mm diameter intrapelvic portal to the hip through the acetabular wall with a commercial hole-saw (**Fig 1B**). The coring guide was temporarily removed to, through the created portal, manually cut the femoral head with a standard oscillating saw and prepare the femoral canal with standard instruments (**Fig 1C**). The coring guide was placed back on the pelvis, allowing us to fix the pelvis and femur to a base in a pre-defined position. Then, we guided a standard calcar planer with a specimen-specific guide to set the planned depth of the neck cut (**Fig 1D**) and cemented the femoral stem (**Fig 1E**). The final position of the intrapelvic hip was verified during implantation through fluoroscopy (**Fig 1F**) and postoperatively through the CT-scan. All hips were tested on a six degree-of-freedom robotic manipulator (KR300 Ultra 2500, KUKA), equipped with hip-specific software (SimVitro, Cleveland Clinic), following our previously published protocol [4]. The anterior and posterior capsule were tested by rotating the femur to impingement at 10° extension and 90° flexion, respectively. Paired t-tests were used to evaluate differences in component position, changes to leg length and femoral offset, and the anterior and posterior capsular torques at impingement between DAA and matched intrapelvic hips at a significance level of 0.05 (MATLAB, MathWorks).

RESULTS: The position of the DAA components, measured on the postoperative scans, was 35°±6° cup inclination, 26°±20° cup anteversion, 5°±1.6° femoral varus/valgus, and 46°±20° combined anteversion. Intrapelvic implantation of the components achieved high accuracy (**Fig 2A**) with acetabular cup inclination and anteversion errors of 2.3°±2.5° (p=0.68) and 1.1°±1.1° (p=0.14) and femoral stem varus/valgus and combined anteversion errors of 2.1°±1.6° (p=0.06) and 34°±24° (p=0.06), respectively. Postoperative leg length differences between DAA and intrapelvic hips were minimal (p=0.86; **Fig 2B**) as were differences in femoral offset (p=0.50; **Fig 2C**). The anterior hip capsule torque was greater (p=0.05) in intrapelvic specimen (4.81±0.56 Nm) than in DAA specimen (1.41±1.55 Nm) (**Fig 2D**). Meanwhile, similar torque at impingement was observed in the posterior (p=0.21) region of the capsule (**Fig 2E**) for DAA (1.24±1.25 Nm) and intrapelvic (2.07±0.83 Nm) approaches.

DISCUSSION: Our preliminary results support the ability of the intrapelvic technique to achieve comparable accuracy in component position to robotically assisted THA acetabular cup inclination (1.6°), anteversion (1.0°) and femoral stem varus/valgus (2.0°).[5,6] While combined anteversion was slightly more variable, it is also seen to vary widely in literature, with a reported range of 20°-70° [7]. Leg length and femoral offsets were similar between techniques. Consequently, the torques in the posterior capsule, which remained intact in all cases were similar for both approaches, confirming our hypothesis. However, contrary to our hypothesis, the torques in the anterior capsule differed slightly between approaches. Such differences could be caused by the difference in anterior capsular status: dissecting for standard DAA THA and intact for intrapelvic THA. These results support the use of the intrapelvic technique to maintain soft tissue integrity and investigate ligament contributions to hip stability without the inherent limitations of a compromised capsule or the need for specialized components that differ from standard implants.

SIGNIFICANCE / CLINICAL RELEVANCE: This novel, intrapelvic THA technique preserves the entire hip capsule's soft tissue integrity while achieving component positioning comparable to standard THA. The method enables controlled biomechanical testing without initial hip capsule violation and using standard implants, offering a powerful model to study postoperative joint stability.

REFERENCES: [1] *AJRR* 2023 [2] Elkins, 2012 *JOR* [3] Van Arkel, 2018 *JBJS* [4] Bido, 2024 *J Arthroplasty* [5] Nodzo, 2018 *BJJ* [6] Teh, 2023 *J Orthopaedics* [7] Jackson, 2020 *Arthroplasty Today*

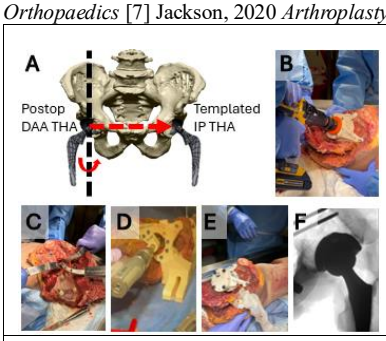

Figure 1 Intrapelvic guides are designed based on (A) component position then (B-F) 3D printed for intraoperative use.

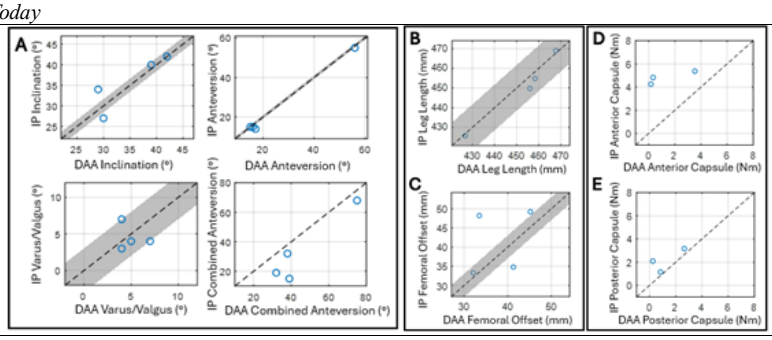

Figure 2 The intrapelvic (IP) approach has comparable (A) cup and stem inclination, anteversion, and varus/valgus (B) leg length (C) femoral offset and (D-E) tissue torques to the DAA approach.