Thesis

Evaluating the Impact of Anatomical Restoration of Hip Offset and Leg Length on One Year THR Outcomes

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Abstract

Background: Restoration of femoral offset and leg length is vital for optimizing biomechanics and patient satisfaction following total hip arthroplasty (THA). Discrepancies exceeding 5 mm have been linked to gait disturbances, abductor weakness, and persistent pain, but the impact of minor deviations remains unclear.

Methods and Materials: In this prospective cohort study, 150 patients (102 males, 48 females; median age 51 years, IQR 39–60) underwent unilateral uncemented THA between October 2019 and December 2021. Standardized anteroposterior pelvic radiographs were obtained preoperatively and six weeks postoperatively. Acetabular offset, femoral offset, global offset (sum of acetabular and femoral), and leg length discrepancy (LLD) were measured using established techniques, with inter observer reliability assessed via intraclass correlation coefficients (ICCs). Patients were stratified into anatomical reconstruction (offset and LLD ≤5 mm; n = 112) and non anatomical (either parameter >5 mm; n = 38) groups

Results: ICCs for offset and LLD measurements exceeded 0.89. Both groups showed significant improvements across all functional scores ($p < 0.0001$). At 12 months, the anatomical cohort achieved higher mean HHS (92 ± 6 vs. 88 ± 7; $p = 0.02$) and lower VAS pain (1.2 ± 0.8 vs. 1.8 ± 1.0; $p = 0.01$). SF 36 physical component scores were superior in the anatomical group (54 ± 8 vs. 49 ± 9; $p = 0.01$).

Conclusion: Meticulous restoration of femoral offset and leg length within 5 mm of the native hip significantly enhances functional recovery and pain relief after THA.

Keywords: Total Hip Arthroplasty; Femoral Offset; Leg Length Discrepancy; Functional Outcome; Radiographic Measurement

Background

Total hip arthroplasty is recognized as one of the most successful orthopedic procedures for alleviating pain and restoring function in end stage hip osteoarthritis [1]. Optimal biomechanical restoration—particularly femoral offset and leg length equality—is essential for balancing abductor muscle tension, minimizing wear, and preventing complications such as limp, dislocation, or neuropathy [2,3]. Femoral offset influences the lever arm of the gluteus medius; inadequate offset may lead to abductor weakness and altered gait, whereas excessive offset can increase joint reaction forces and risk of trochanteric pain [4–6]. Leg length discrepancy after THA


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DOI: https://doi.org/10.13107/jmt.2024.v10.i02.252

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affects patient satisfaction, gait symmetry, and may contribute to lower back pain [7–9]. Previous studies suggest that discrepancies greater than 5 mm correlate with poorer outcomes; however, the clinical significance of small deviations remains uncertain [10–12]. This study aims to clarify the threshold at which offset and LLD alterations materially impact functional recovery.

Aims and Objectives

1. To quantify changes in global femoral offset and leg length following uncemented THA.
2. To compare clinical outcomes between patients with offset/LLD differences ≤5 mm versus >5 mm.
3. To evaluate correlations between precise anatomic restoration and patient reported outcomes (HHS, WOMAC, OHS, SF 36, VAS) over one year.

Materials and Methods

Study Design and Setting

A single center, prospective cohort study was conducted at [Institution Name] from October 2019 to December 2021. Institutional ethics approval and written informed consent were obtained.

Patient Selection

Inclusion criteria: patients aged 18–80 years with primary osteoarthritis undergoing unilateral, uncemented THA. Exclusion criteria: congenital hip deformities, bilateral THA, post traumatic arthritis, inflammatory arthropathies, neuromuscular disorders, or previous hip surgery.

Radiographic Assessment

Standardized anteroposterior pelvis radiographs with 15° internal rotations were obtained preoperatively and at 6 weeks postoperatively. Measurements were performed on digital PACS by two independent observers, with intra and inter observer reliability assessed by intraclass correlation coefficients (ICC).

- Acetabular Offset (AO): Distance from the teardrop line to the center of the femoral head [13].
- Femoral Offset (FO): Perpendicular distance from the femoral shaft axis to the center of the femoral head [14].
- Global Offset (GO): Sum of AO and FO.
- Leg Length Discrepancy (LLD): Vertical distance from inter teardrop line to the apex of the lesser trochanter, compared bilaterally using the Woolson method [15].

Patients were classified as anatomically reconstructed if both GO and LLD differences were ≤5 mm relative to the contralateral hip; those with either parameter >5 mm comprised the comparison group.

Clinical Outcomes and Follow Up

Outcomes were assessed preoperatively and at 6 weeks, 6 months, and 12 months by a blinded assessor.

- Modified Harris Hip Score (HHS) [16].
- Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) [17].
- Oxford Hip Score (OHS) [18].
- Short Form 36 (SF 36) physical and mental component summaries [19].
- Visual Analog Scale (VAS) for pain (0–10).

Surgical Technique and Postoperative Care

All procedures employed a posterolateral approach under spinal or general anesthesia. Uncemented titanium alloy femoral stems and hydroxyapatite coated cups were used. Intraoperative templating guided implant selection to approximate native offset and leg length. Postoperatively, patients received standardized physiotherapy focusing on early mobilization, muscle strengthening, and gait training. Deep vein thrombosis prophylaxis (low molecular weight heparin for five days) and antibiotic prophylaxis (intravenous for 48 hours, then oral for five days) were administered [20].

Statistical Analysis

Data were analyzed using SPSS v25.0. Continuous variables are reported as mean ± standard deviation or median (IQR) based on distribution; categorical variables as counts (%). ICC evaluated measurement reliability. Linear mixed effects models examined changes in functional scores over time and compared trajectory differences between reconstruction groups, adjusting for age, sex, and body mass index. A p value <0.05 was considered statistically significant.

Results

Participant Characteristics

Of 173 eligible patients, 150 (86.7%) completed the one year follow up. In the anatomically reconstructed group (n = 112), the mean age was 50.8 ± 9.2 years, with 32.1% female participants, an average BMI of 25.6 ± 3.4 kg/m², and comorbidities including hypertension (30.4%) and diabetes (12.5%). The non anatomical group (n = 38) had a mean age of 52.1 ± 8.7 years, 31.6% females, an average BMI of 26.1 ± 3.7 kg/m², hypertension in 36.8% of patients, and diabetes in 21.1%. There were no statistically significant differences between the groups in baseline demographics or comorbidity profiles, indicating comparability at enrollment.

Radiographic Outcomes

Radiographic assessment at six weeks postoperatively demonstrated excellent measurement reliability, with inter observer ICCs of 0.92 for global offset and 0.89 for leg length discrepancy ($p < 0.001$). In the anatomically reconstructed cohort, the mean global offset difference relative to the contralateral hip was 1.8 ± 1.2 mm, compared to 7.4 ± 2.5 mm in the non anatomical group ($p < 0.001$). Similarly, the mean LLD

was 2.3 ± 1.5 mm in the anatomical group versus 9.2 ± 3.1 mm in the non anatomical group ($p < 0.001$), confirming effective stratification based on the 5 mm threshold.

Functional Outcomes

Both cohorts exhibited significant improvements across all functional metrics from baseline to one year ($p < 0.0001$). At 12 months, the anatomical group achieved a higher mean Modified Harris Hip Score (92 ± 6) than the non anatomical group (88 ± 7; $p = 0.02$) and reported lower pain on the Visual Analog Scale (1.2 ± 0.8 vs. 1.8 ± 1.0; $p = 0.01$). Although the anatomical group demonstrated better improvements in WOMAC and Oxford Hip Score, these differences did not reach statistical significance (WOMAC: $p = 0.08$; OHS: $p = 0.10$). Notably, the anatomical cohort also recorded a superior SF 36 physical component summary score (54 ± 8 vs. 49 ± 9; $p = 0.01$). No dislocations or revisions were observed in either group, and only three patients in the non anatomical group reported a persistent limp at one year.

Age, years (mean ± SD)	50.8 ± 9.2	52.1 ± 8.7	0.45
Female, n (%)	36 (32.1)	12 (31.6)	0.95
BMI, kg/m² (mean ± SD)	25.6 ± 3.4	26.1 ± 3.7	0.38
Hypertension, n (%)	34 (30.4)	14 (36.8)	0.47
Diabetes, n (%)	14 (12.5)	8 (21.1)	0.19

Radiographic Outcomes

Inter observer ICC for GO and LLD measurements were 0.92 and 0.89, respectively ($p < 0.001$). At six weeks, the anatomical group showed mean GO difference of 1.8 mm (±1.2) versus 7.4 mm (±2.5) in the non anatomical group ($p < 0.001$). Mean LLD difference was 2.3 mm (±1.5) versus 9.2 mm (±3.1), respectively ($p < 0.001$).

Functional Outcomes

Both groups experienced significant improvements in HHS, WOMAC, OHS, SF 36, and VAS over time (all $p < 0.0001$). At 12 months, the anatomical group achieved higher mean HHS (92 ± 6 vs. 88 ± 7; $p = 0.02$) and lower VAS pain scores (1.2 ± 0.8 vs. 1.8 ± 1.0; $p = 0.01$). WOMAC and OHS differences favored anatomical restoration but did not reach statistical significance ($p = 0.08$ and 0.10, respectively). SF 36 physical component was significantly better in the anatomical group (54 ± 8 vs. 49 ± 9; $p = 0.01$).

Discussion

This study demonstrates that precise surgical restoration of femoral offset and leg length within 5 mm results in superior hip function and pain relief following THA. High ICC values confirm radiographic measure reliability. Although both groups improved significantly, patients in the anatomical restoration cohort attained higher HHS, better pain relief, and improved physical quality of life.

Our findings corroborate earlier biomechanical studies linking offset restoration to optimized abductor firing and reduced joint reaction forces [2,4,5]. The observed differences in HHS and SF 36 physical scores, albeit modest, highlight the clinical relevance of small anatomic deviations. This extends prior work suggesting that offsets beyond 5 mm can impair gait and muscle strength [6,10]. Likewise, our LLD results align with literature indicating that discrepancies >5 mm contribute to limp and patient dissatisfaction [7,8].

Strengths of this study include standardized radiographic technique, prospective design, blinded outcome assessment, and robust statistical modeling to adjust for confounders. The use of multiple validated outcome measures provides a comprehensive evaluation of patient recovery.

Limitations encompass single center scope, short term follow up limited to one year, and potential selection bias as a tertiary referral population. Future research should focus on multicenter trials, longer follow up to assess implant longevity and wear patterns, and investigation of patient specific templating technologies such as 3D planning and intraoperative navigation.

Conclusion

Meticulous restoration of femoral offset and leg length within 5 mm significantly improves functional outcomes, pain relief, and physical quality of life after uncemented THA. Standardized radiographic protocols and careful surgical technique are key to achieving optimal results.

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Conflict of Interest: Nil
Source of Support: None

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University Affiliation: MUHS, Nashik, Maharashtra, India.
Year of Acceptance of Thesis: 2019

How to Cite this Article: How to Cite this Article: Patil P, Joshi R, Sanghavi S, Dugad M, Sonawane D, Shyam A, Sancheti P.| Evaluating the Impact of Anatomical Restoration of Hip Offset and Leg Length on One-Year THR Outcomes | Journal of Medical Thesis | 2025 July-December; 11(2):44-47.