Hypothesis

Clinical Hypothesis: Does Achieving Combined ±5 mm Restoration Enhance Abductor Strength and Reduce Limp after THA?

Pavan Patil[1],
Rajeev Joshi[1],
Sahil Sanghavi[1],
Mahavir Dugad[1],
Darshan Sonawane[1],
Ashok Shyam[1],
Parag Sancheti[1]

[1]Department of Orthopaedics, Sancheti Institute of Orthopaedics and Rehabilitation, Pune, Maharashtra, India.

Address of Correspondence
Dr. Pavan Patil,
Department of Orthopaedics, Sancheti Institute of Orthopaedics and Rehabilitation, Pune, Maharashtra, India.
E-mail: drpavan010@gmail.com

Abstract

Background: Total hip replacement (THR) aims to relieve pain and restore function. Restoring leg length and femoral/acetabular offset is important for abductor mechanics and gait symmetry. Small deviations can cause limp, back pain, dissatisfaction, and may affect abductor strength and gait despite good pain relief. The cohort included consecutive patients with 12-month follow-up and combined clinical and instrumented gait assessments for analysis. This study analyzed patients undergoing primary THR, measuring postoperative leg length discrepancy (LLD) and global offset on standardized radiographs and comparing these with patient-reported outcome measures (Harris Hip Score, WOMAC, Oxford Hip Score, SF-36, VAS), abductor strength and gait parameters up to one year.

Hypothesis: Restoring both leg length and global offset to within ±5 mm of the contralateral hip leads to better objective gait performance and abductor strength at one year compared with greater discrepancies. While PROMs improve broadly after THR, it is expected that patients with well-restored geometry will show superior walking speed, symmetry and muscle power, and possibly modestly better function-related PROM subscales.

Clinical importance: For surgeons, combined restoration of length and offset is a practical, modifiable goal that supports a more natural gait and stronger abductor function. Achieving geometry within ±5 mm reduces the risk of persistent limp, perceived limb difference and related back pain. When patients report unexplained limp or dissatisfaction after otherwise successful THR, a focused assessment of LLD and offset can identify correctable mechanical causes and guide targeted interventions.

Future research: Larger multicentre studies using precise 3D imaging and standardized gait analysis are needed to determine whether small early biomechanical deficits lead to increased wear or revision in the long term. Development of PROM subscales sensitive to gait asymmetry and wider adoption of intraoperative navigation or rapid templating tools may improve reproducibility of reconstructing hip geometry and patient outcomes.

Keywords : Total hip replacement, Leg length discrepancy, Femoral offset, Gait, Abductor strength, Patient-reported outcomes


Dr. Pavan Patil

Dr. Rajeev Joshi

Dr. Sahil Sanghavi

Dr. Mahavir Dugad


Dr. Darshan Sonawane


Dr. Ashok Shyam


Dr. Parag Sancheti

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Background

Total hip replacement (THR) has transformed the lives of many patients with painful, disabling hip arthritis. The operation reliably reduces pain, restores mobility and improves quality of life. However, success after THR is not simply relief of pain — restoring the hip's normal mechanics matters too. Two technical details that surgeons try to restore are leg length and femoral/acetabular offset. Small errors in these parameters can change muscle mechanics, alter gait, and leave patients with limp, back pain or dissatisfaction despite a well-fixed implant.

Femoral offset is the horizontal distance from the center of the femoral head to the femoral axis. It controls the abductor muscles' lever arm: reduce the offset and the abductors lose mechanical advantage and must work harder to stabilize the pelvis; increase it too much and the soft tissues are overtensioned and joint forces rise. This biomechanical balance is directly tied to walking ability and to the feeling of a "normal" hip after surgery [1–4]. Multiple clinical studies have linked offset loss (particularly reductions >5 mm) with weaker abductor strength and worse functional test results [5–8].

Leg length discrepancy (LLD) after THR is another frequent cause of patient concern. Perceived or real limb length differences may produce a limp, low-back pain, or a sense that the leg "feels" different; substantial overlengthening can even cause nerve stretch injuries. Careful templating, technique and intraoperative checks reduce the risk, but plain radiographs used for measurement can be affected by pelvic tilt or rotation, which complicates exact measurement [9–13]. Many surgeons use a pragmatic tolerance — ±5 mm for length and offset — reasoning that differences within this window are unlikely to be clinically meaningful for most patients [14,15]. But that rule of thumb is not absolute: gait lab studies and focused strength testing often detect changes even when patient-reported outcome measures (PROMs) look acceptable. This suggests PROMs can be insensitive to subtle biomechanical problems that still matter to function [16–18].

The literature shows mixed findings. Large registry and some retrospective studies find weak or inconsistent associations between radiographic measures and PROMs, possibly because PROMs emphasize pain relief and broad activities rather than fine gait symmetry. By contrast, detailed gait analyses and dynamometry frequently show biomechanical deficits tied to offset or length errors — deficits that can persist even after pain disappears [19–21]. The attached thesis explores these tensions by prospectively measuring postoperative LLD and global offset on standardized radiographs and comparing them with PROMs (Harris Hip Score, WOMAC, Oxford Hip Score, SF-36, VAS), abductor strength testing and gait parameters up to 12 months after primary THR. The study asks whether achieving combined restoration of length and offset to within clinician-accepted tolerances corresponds with better objective function as well as with better patient-reported outcomes [22–25].

Hypothesis

Primary hypothesis (null): Restoration of limb length and global offset after primary total hip replacement does not influence clinical outcomes measured by validated PROMs and objective functional tests at one year.

Alternative (working) hypotheses:

1. Patients whose combined postoperative leg length and global offset are within ±5 mm of the contralateral native hip will demonstrate superior objective gait performance (higher normalized walking speed, more symmetric stance phases and improved hip range of motion during gait) at 12 months compared with patients with >5 mm discrepancy.
2. Restoration of femoral/ global offset — and specifically avoiding a reduction of offset >5 mm — will associate with greater abductor muscle strength and improved functional scores.
3. The effects of LLD and offset are additive: combined deviations beyond 5 mm will produce more pronounced gait asymmetry and symptomatic complaints, even in the setting of overall pain relief.

Rationale

The abductor mechanism stabilizes the pelvis during single-leg stance. If the offset is reduced, the abductor lever arm shortens and the muscles must generate more force to maintain the same moment, which can produce fatigue, weakness and an observable Trendelenburg sign or limp [1–4]. Conversely, excessive offset increases soft-tissue tension and joint reaction forces, potentially causing pain or accelerated wear [5,6]. Leg length differences change limb loading and timing of gait phases — even small asymmetries can alter step length and ground reaction forces and are readily observed on instrumented gait analysis [7,8].

PROMs such as the Harris Hip Score or WOMAC measure pain, stiffness and broad function, and they usually improve markedly after THR. But these tools may not detect fine mechanical deficits. Therefore, coupling PROMs with objective tests (gait analysis, dynamometry) increases sensitivity to clinically meaningful biomechanical effects [16–18]. The ±5 mm threshold is a commonly used clinical target based on a mix of biomechanical reasoning and empirical study; here it serves as the operational definition for "restored" geometry [14,15].

Operational definitions and endpoints

- Restored geometry: combined LLD and global offset within ±5 mm of the contralateral limb.
- Primary endpoints: PROMs (HHS, WOMAC, Oxford Hip Score), normalized walking speed and key gait symmetry measures at 12 months.
- Secondary endpoints: abductor torque on dynamometry, incidence of symptomatic LLD (patient complaint or requirement for heel lift), and complications related to

mechanical imbalance (persistent limp, back pain, instability).
Expected outcome. It is expected that, while most patients will experience pain relief and improved PROMs, the subgroup with well-restored geometry will show clearer advantages on objective functional measures and strength testing, and possibly modest but measurable advantages on PROM subscales related to function and satisfaction.

Discussion

The study described in the thesis supports a practical, biomechanically informed approach to THR: strive for accurate restoration of leg length and offset together. In the cohort, when both parameters were kept within ±5 mm of the contralateral hip, patients tended to show better gait symmetry and stronger abductor function than those with larger deviations. Across the entire cohort, pain scores and global PROMs improved substantially after surgery, which is consistent with existing literature that emphasizes the profound analgesic benefit of THR [19–21].
Why, then, do some large studies find only weak associations between radiographic measures and PROMs? The likely explanation is that PROMs emphasize pain relief and global mobility — they capture sweeping improvements — whereas biomechanical tests pick up subtler deficits such as slight gait asymmetry or reduced power in abductor muscles. A patient may feel much less pain and report good general function while still walking with slight limp due to reduced lever arm or a small LLD. Thus, PROMs and objective measures are complementary; both matter, but they answer different clinical questions [16–18].
Measurement technique matters. Standard AP pelvic radiographs are commonly used to measure leg length and offset, but they have limitations. Pelvic rotation, tilt and magnification can introduce errors, and radiographic landmarks vary with patient positioning. CT offers more precise three-dimensional measurement but is not routine for all THR patients. Because of radiographic variability, consistent imaging technique and intraoperative checks (templating, limb comparison methods, and measured trial reductions) remain essential to minimize systematic errors [9–13].
The thesis also highlights additive effects: patients with simultaneous small errors in both offset and length tended to fare worse on gait tests than those with a single small abnormality. This finding argues for planning and executing reconstruction with attention to both parameters together rather than optimizing one while neglecting the other. In practice, adjustments to cup position, stem choice and neck version can be used to balance offset and length intraoperatively, but decisions must be individualized to anatomy and soft tissue tension.

Limitations deserve mention

The single-center design and follow-up limited to 12 months constrain generalizability and preclude assessment of long-term wear or implant survival linked to offset misreconstruction. The sample size, while reasonable, might not detect very small differences in PROM subscales. Finally, surgical approach, implant design and patient anatomy vary, so numerical thresholds such as ±5 mm should be interpreted as pragmatic targets rather than absolute rules [22–25].
In clinical practice, the practical implications are clear: careful preoperative templating, consistent intraoperative technique, and postoperative assessment that includes both PROMs and, where feasible, objective gait or strength testing provide the best chance of identifying and correcting mechanical problems that may reduce patient satisfaction.

Clinical importance

Restoring leg length and offset in THR is a modifiable surgical factor that directly affects function. Aiming for combined restoration within ±5 mm of the native hip is a practical target that reduces risk of persistent limp, abductor weakness and patient dissatisfaction. While pain relief after THR is usually dramatic regardless, mechanical symmetry contributes to a more natural gait and better muscular function. Surgeons should use templating, consistent radiographic technique and intraoperative checks to minimize discrepancies. When patients complain of residual limp, back pain or a feeling that the leg is "different" despite an otherwise successful operation, focused evaluation of LLD and offset (and gait analysis when available) can uncover correctable mechanical causes.

Future directions

Future work should focus on multicenter prospective studies that combine precise 3D imaging (CT), standardized gait analysis and long-term implant outcomes to determine whether small early biomechanical deficits translate into increased wear or revision risk. Development of more sensitive functional PROM subscales that capture gait asymmetry and abductor weakness would help align patient reports with objective measures. Wider use of intraoperative navigation or rapid templating technologies could reduce measurement error and make geometric reconstruction more reproducible. Finally, long-term follow-up is needed to know whether modest early deviations in offset or length affect implant longevity, patient satisfaction and musculoskeletal health over decades.

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Institute Where Research was Conducted: Department of Orthopaedics, Sancheti Institute of Orthopaedics and Rehabilitation, Shivajinagar, Pune, Maharashtra, India.
University Affiliation: MUHS, Nashik, Maharashtra, India.
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