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The role of detailed pelvic anatomy in improving surgical outcomes of total hip replacement

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Abstract
Introduction and Background: Many patients with advanced hip joint pathology, such as osteoarthritis, avascular necrosis, or hip fractures, choose for total hip replacement (THR) surgery. Concerns about instability, neurovascular damage, and implant malpositioning persist despite the procedure's success. Patients undergoing THR will be the focus of this investigation of the effects of a thorough anatomical approach on surgical precision, postoperative problems, and functional recovery.
Materials and Methods: Participants were 120 individuals who underwent primary total heart replacement (THR) between July 2017 and June 2018 at the department of General Surgery, I- Care Institute of Medical Sciences and Research, Haldia, West Bengal, India. There were two groups of patients given random assignments: one group (n=60) underwent the procedure using a conventional anatomical approach, and the other group (n=60) underwent the procedure with a comprehensive pelvic anatomical evaluation, which included preoperative CT-based planning and intraoperative navigation. Patients meeting the inclusion criteria had to have femoral head avascular necrosis or end-stage hip osteoarthritis in order to undergo THR.
Results: A considerably reduced frequency of acetabular cup malpositioning (4.5% vs. 15% in Group A, $p<0.01$) and leg length disparity larger than 5mm (3.3% vs. 13.3%, p=0.02) was observed in patients in Group B, where full pelvic anatomical examination was carried out.** Group B had 1.7% of cases with neurovascular problems, but Group A had 8.3% (p=0.04). These issues included irritation of the sciatic nerve and injury to the superior gluteal artery. Group A had lower WOMAC pain scores at 6 months postoperatively and higher postoperative functional scores, with an average HHS score of 88.5 ± 6.2 compared to 81.3 ± 7.1 in Group B (p=0.001).
Conclusion: Accurate acetabular cup placement, decreased risk of neurovascular problems, and improved functional recovery after total hip replacement are all outcomes of thorough preoperative and intraoperative pelvic anatomy education. In order to maximize surgical success and long-term patient mobility, these data highlight the importance of improved anatomical training and preoperative planning in hip arthroplasty.

Keywords: Total hip replacement, pelvic anatomy, acetabular orientation, surgical outcomes, and neurovascular complications

Introduction
Patients with advanced hip pathology, such as osteoarthritis, rheumatoid arthritis, avascular necrosis, or hip fractures, might find considerable pain relief and functional improvement with total hip replacement (THR), one of the most popular and effective orthopedic surgeries. Surgical results and patient satisfaction are nevertheless affected by issues such implant mispositioning, leg length disparity, prosthesis instability, and neurovascular injuries, even though the procedure has a high success rate [1-3].
To maximize the success of THR, a thorough familiarity with pelvic anatomy is essential. Implant stability and durability are greatly affected by the acetabular orientation, which is determined by the acetabular anteversion and inclination angles. Prosthetic survivorship can be compromised due to misaligned acetabular components, which can cause dislocation, higher wear, and decreased range of motion. In order to avoid problems like nerve palsy or excessive bleeding, the neurovascular and vascular structures, such as the sciatic nerve, femoral nerve, obturator nerve, and superior gluteal artery, need to be meticulously navigated during the surgery [2-4].
Manual placement and intraoperative anatomical landmarks are the backbone of traditional THR approaches; nevertheless, these methods have their limitations due to surgeon bias and patient anatomy. Accurate guidance for acetabular cup implantation and femoral component alignment has been made possible by recent advancements in intraoperative navigation and preoperative

imaging (CT-based planning) [3-5]. Together, our improved knowledge of pelvic anatomy and these technical developments might drastically cut down on mistakes and boost functional results in the long run [4-6].
Improving surgical precision, minimizing complications, and boosting postoperative recovery in total hip replacement (THR) are the goals of this study, which seeks to evaluate the importance of extensive pelvic anatomical examination [5-7]. Our goal is to demonstrate the significance of a thorough anatomical approach on implant placement, neurovascular complications, and functional recovery after THR by contrasting results between a conventional approach and a comprehensive pelvic anatomical evaluation [6-8].

Materials and Methods
This prospective study comprised 120 patients who were part of a main total hip replacement (THR) program at a tertiary care orthopedic center in India. The program ran from July 2017 to June 2018 at the I-Care Institute of Medical Sciences and Research in Haldia, West Bengal. The major objective of the study was to discover how a comprehensive assessment of pelvic anatomy affected surgical precision, implant placement, postoperative functional outcomes, and neurovascular complications. A total of 120 patients were randomly assigned to one of two groups for the procedure. One group had the standard anatomical approach, with 60 patients in that group, while the other group had a more thorough pelvic anatomical evaluation, with 60 patients in that group, which included intraoperative navigation and preoperative CT-based planning.

Inclusion Criteria
- Patients aged 45-75 years with primary hip osteoarthritis, avascular necrosis
- Patients with adequate bone stock for primary implant fixation.
- Patients willing to provide informed consent and follow up for at least 6 months

Exclusion Criteria
- Patients with a history of previous hip surgery or congenital hip deformities affecting acetabular morphology.
- Presence of severe osteoporosis (T-score < -2.5)
- Patients with neuromuscular disorders that could impact gait and mobility.

Results
In all, 120 patients were a part of the research; 60 of them were assigned to the "Standard Approach" group and 60 to the "Detailed Anatomy Approach" group. Patients in both groups were statistically similar to one another in terms of age, gender, body mass index (BMI), and functional scores taken before surgery ($p > 0.05$).

Implant Positioning Accuracy
Group B had a substantially higher rate of acetabular cup positioning inside the Lewinnek safe zone (95% vs. 85% in Group A, p = 0.03). This zone includes an inclination of 30°-50° and an anteversion of 5°-25°. Nine cases (15%) of malpositioned acetabular cups were found in Group A, while only three cases (5% of the total) were found in Group B.

Table 1: Accuracy of Acetabular Cup Positioning in Total Hip Replacement

Parameter	Group A (Standard Approach) (n=60)	Group B (Detailed Anatomy Approach) (n=60)	p-value
Acetabular cup within safe zone (%)	85% (51 cases)	95% (57 cases)	0.03
Acetabular cup malposition (%)	15% (9 cases)	5% (3 cases)	0.03
Mean cup inclination (°)	43.2 ± 5.6	40.8 ± 4.2	0.04
Mean cup anteversion (°)	17.5 ± 6.1	14.9 ± 4.8	0.02

Leg Length Discrepancy
Group B had a more accurate implant alignment, as 13.3% of Group A patients had a significant leg length discrepancy (LLD > 5mm) whereas only 3.3% of Group B patients did (p = 0.02).

Table 2: Leg Length Discrepancy in Total Hip Replacement Patients

Leg Length Discrepancy (LLD > 5mm)	Group A (Standard Approach) (n=60)	Group B (Detailed Anatomy Approach) (n=60)	p-value
Present (%)	13.3% (8 cases)	3.3% (2 cases)	0.02
Mean LLD (mm)	4.7 ± 2.1	2.8 ± 1.5	0.01

Neurovascular Complications
There was a statistically significant difference between Groups A and B in the frequency of neurovascular problems, such as sciatic nerve irritation, femoral nerve palsy, and injury to the superior gluteal artery (8.3% vs.1.7%).

Table 3: Incidence of Neurovascular Complications in Total Hip Replacement

Neurovascular Complications	Group A (Standard Approach) (n=60)	Group B (Detailed Anatomy Approach) (n=60)	p-value
Sciatic nerve irritation (%)	3.3% (2 cases)	0%	0.08
Femoral nerve palsy (%)	3.3% (2 cases)	1.7% (1 case)	0.12
Superior gluteal artery injury (%)	1.7% (1 case)	0%	0.09
Total complications (%)	8.3% (5 cases)	1.7% (1 case)	0.04

Functional Outcomes
A functional recovery assessment was conducted at the 6-month follow-up using the Harris Hip Score (HHS) and the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) Pain Score. Group B showed better results in terms of lower WOMAC pain scores (p = 0.03) and higher HHS scores (88.5 ± 6.2 vs. 81.3 ± 7.1, p = 0.001), suggesting better improvement in mobility and alleviation from pain.

Table 4: Functional Outcomes at 6-Month Follow-up in Total Hip Replacement Patients

Functional Outcomes	Group A (Standard Approach) (n=60)	Group B (Detailed Anatomy Approach) (n=60)	p-value
Mean Harris Hip Score	81.3 ± 7.1	88.5 ± 6.2	0.001
Mean WOMAC Pain Score	12.4 ± 3.8	8.7 ± 3.1	0.03

Discussion

Precise implant placement and preservation of neurovascular systems are crucial for good outcomes in total hip replacement (THR), a well-established surgical surgery for hip joint diseases. Improved implant accuracy, reduced complications, and enhanced functional recovery can be achieved with a comprehensive pelvic anatomical assessment that includes preoperative CT-based planning and intraoperative navigation. This was demonstrated in the present study [9-11].

Because misalignment can cause dislocation, increased wear, impingement, and decreased range of motion, proper acetabular cup placement is a key component of a successful THR. Our investigation found a statistically significant difference between the two groups: patients whose acetabular cups were positioned inside the Lewinnek safe zone were more likely to have undergone extensive anatomical examination [12-14]. The detailed anatomy group also had far more favorable mean inclination and anteversion angles, proving that preoperative imaging and surgical guiding are beneficial. Consistent with earlier studies, our results show that CT-based preoperative planning and computer-assisted navigation both enhance implant location and decrease variability [15-17].

A common issue that patients face after total hip replacement (THR) is leg length discrepancy (LLD). Even a small difference can lead to issues with the patient's gait, back pain, and overall satisfaction with the procedure. Compared to the usual method group, patients in the detailed anatomy group had a substantially reduced rate of discrepancies larger than 5 mm, and LLD was substantially lower in that group as well. Postoperative difficulties related to limb asymmetry can be reduced with improved femoral stem placement and limb length equalization, which in turn is enabled by a more comprehensive anatomical examination [18-20].

A major risk of total hip replacement is nerve damage; the sciatic nerve, femoral nerve, and superior gluteal artery are especially at risk. Our investigation revealed that the detailed anatomy group had a markedly reduced risk of neurovascular problems when compared to the traditional technique. This suggests that the utilization of preoperative imaging and intraoperative navigation enhanced the visibility of vital neurovascular structures. Surgeons were able to adjust their techniques based on the improved visibility, which presumably reduced the occurrence of nerve palsy and vascular harm. These results highlight the need of thorough anatomical assessment in lowering intraoperative risks and raising the bar for safe surgical results [19-21].

Functional recovery, reduced pain, and patient satisfaction are the end goals of total hip replacement (THR). Patients who had more precise anatomical assessments during their surgeries had better functional recovery, as shown by higher Harris Hip Scores and lower WOMAC pain scores. Consistent with earlier research, this study found that appropriate implant placement was associated with superior long-term patient-reported outcomes, lower complication rates, and less risk of implant failure.

The results of this study show that intraoperative navigation and preoperative imaging are crucial in contemporary THR procedures. Surgeons can improve long-term results, reduce problems, and increase precision by including thorough pelvic anatomy into surgery planning. Modern imaging and navigational technologies are useful supplements to traditional landmark-based methods, especially for difficult cases and patients at high risk [24-26].

Conclusion

The results may not be applicable to a broader population because the study only used data from one institution and had a small sample size. Additionally, long-term implant survival rates were not evaluated, and the duration of the follow-up was only six months. To determine how long the benefits of surgery last, future studies should involve bigger, multicenter trials with longer follow-up times. It is also important to undertake cost-effectiveness evaluations to find out if using advanced imaging techniques in everyday clinical practice is feasible. Ultimately, this study proves that thorough pelvic anatomy evaluations, such as computed tomography (CT)-based preoperative planning and intraoperative navigation, considerably boost functional recovery after total hip replacement (THR), decrease neurovascular complications, and improve implant positioning. Incorporating advanced anatomical examination into standard THR methods improves patient outcomes, as shown in these results.

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None

Conflict of Interest

None

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