



Original Article

Radiological Outcomes Following Total Hip Replacement: A Prospective Evaluation of Implant Stability and Osteointegration

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ABSTRACT

Background: Total hip replacement (THR) is a highly successful reconstructive procedure for the management of end-stage hip disorders. While clinical outcomes following THR are well documented, radiological assessment remains essential for evaluating implant positioning, osteointegration, component stability, and early postoperative complications. However, data regarding radiological outcomes following THR in rural and tribal populations of central India remain limited.

Objective: To evaluate the radiological outcomes, implant stability, and osteointegration following total hip replacement through serial postoperative radiographic assessment.

Methods: A prospective observational study was conducted in the Department of Orthopaedics, Raipur Institute of Medical Sciences, Raipur, Chhattisgarh, India, over a period of 18 months. Seventy-nine patients undergoing primary THR for end-stage hip pathology were included. Standardized anteroposterior radiographs of the pelvis and operated hip were obtained preoperatively, immediately postoperatively, at 3 months, and at 6 months. Acetabular component assessment was performed using the DeLee and Charnley classification, while femoral component evaluation was based on the Gruen zonal system. Radiographs were analyzed for implant stability, osteointegration, radiolucent lines, component migration, loosening, and osteolysis.

Results: A total of 79 patients were included in the study, with a mean age of 44.16 ± 13.85 years; 61 (77.2%) were males and 18 (22.8%) were females. Serial radiographic evaluation demonstrated satisfactory implant positioning and stability in the majority of patients throughout the follow-up period. Radiolucent lines were observed in DeLee and Charnley Zone III in 5 patients (6.3%) and in Gruen Zone IV in 6 patients (7.5%). No radiolucencies were detected in DeLee and Charnley Zones I and II. There were no cases of component migration, stem subsidence, acetabular or femoral component loosening, or osteolysis during the six-month follow-up period. Stable implant fixation was observed in 74 patients (93.7%), and radiographic findings were consistent with satisfactory osteointegration and biological fixation.

Conclusion: Total hip replacement demonstrated excellent short-term radiological outcomes, with favorable implant positioning, successful osteointegration, and a high rate of implant stability. The limited radiolucencies observed were not associated with implant failure or clinical instability. These findings support the effectiveness of THR in achieving reliable early radiological outcomes in patients from rural and tribal populations and highlight the value of serial radiographic assessment in postoperative surveillance.

Keywords: Total hip replacement; Total hip arthroplasty; Radiological outcome; Osteointegration; Implant stability; DeLee and Charnley classification; Gruen zones; Prospective study.

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INTRODUCTION

Total hip replacement is one of the most successful reconstructive procedures in orthopaedic surgery and has become the standard treatment for end-stage hip disorders, including osteoarthritis, avascular necrosis of the femoral head, rheumatoid arthritis, fracture neck of femur, and other debilitating hip pathologies (Faulkner, Kennedy, Baxter, Donovan, Wilkinson, & Bevan, Effectiveness of hip prostheses in primary total hip replacement: a critical review of evidence and an economic model., 1998; Fokter, Recent Advances in Hip and Knee Arthroplasty, 2012). The primary goals of THR are pain relief, restoration of hip function, correction of deformity, and improvement in quality of life (3,4). Advances in implant design, biomaterials, fixation techniques, and surgical approaches have substantially improved implant survivorship and patient outcomes over the past several decades, with registry data demonstrating survival rates of approximately 78.8% at 20 years and 89.4% at 15 years (95% CI) (5).

Although clinical improvement following THR is of paramount importance, radiological evaluation remains an indispensable component of postoperative assessment (6,7). Serial radiographic examination provides objective information regarding implant positioning, component fixation, osteointegration, restoration of hip biomechanics, and the early detection of complications (7). Accurate radiological assessment allows clinicians to identify implant-related problems such as component migration, radiolucent lines, osteolysis, stem subsidence, heterotopic ossification, and aseptic loosening before the onset of significant clinical symptoms (6,8).

Radiographic analysis of THR has been standardized through the use of established classification systems. The acetabular component is commonly evaluated using the DeLee and Charnley zonal classification (9), while the femoral component is assessed using the Gruen zonal system (6,10). These classifications facilitate systematic assessment of radiolucent lines and implant stability and enable comparison of outcomes across studies (11). Furthermore, the presence of spot welds, trabecular continuity, and absence of progressive radiolucent lines are recognized indicators of successful biological fixation and osteointegration in uncemented prostheses (12–14).

Successful osteointegration and long-term implant stability are critical determinants of prosthesis survival (13,15). Radiological evidence of stable fixation during the early postoperative period is associated with favorable long-term outcomes, whereas progressive radiolucency, migration, and osteolysis may indicate impending implant failure (7,16). Consequently, radiographic follow-up has become an essential component of postoperative surveillance after THR and is routinely incorporated into outcome assessment protocols (6,17).

Despite the increasing number of THR procedures being performed in India, there remains a relative paucity of published data describing radiological outcomes from rural and tribal populations (18,19). Most available evidence originates from urban tertiary-care centres and may not accurately represent the demographic profile, disease spectrum, and healthcare challenges encountered in resource-limited settings (20). Regional differences in patient characteristics, indications for surgery, bone quality, and access to follow-up care may influence radiological outcomes and implant performance.

Radiological assessment provides objective evidence regarding implant fixation, stability, osteointegration, and early complications following total hip replacement (6,7). However, prospective studies evaluating radiological outcomes after THR in rural and tribal populations of central India are limited. Generating local evidence regarding postoperative radiological findings is important for understanding implant performance and ensuring optimal long-term outcomes in these populations. Therefore, the present study was undertaken to evaluate radiological changes and implant stability following total hip replacement.

The present study was undertaken to assess the radiological outcomes of patients undergoing total hip replacement through serial postoperative radiographic evaluation. Specifically, the study aimed to determine implant stability, assess osteointegration, identify radiolucent lines around acetabular and femoral components, and detect early radiographic complications during the six-month follow-up period following surgery (6,9).

METHODS

Study Design and Setting

This prospective observational study was conducted in the Department of Orthopaedics, Raipur Institute of Medical Sciences, Raipur, Chhattisgarh, India, over an 18-month period.

Study Population

Seventy-nine patients undergoing primary THR for end-stage hip pathology were included. All procedures were performed using the posterior Moore approach.

Radiological Evaluation

Standardized anteroposterior radiographs of the pelvis and operated hip were obtained preoperatively, immediately postoperatively, at 3 months, and at 6 months following surgery.

Radiographic Parameters

Radiographs were assessed for component positioning, implant stability, osteointegration, radiolucent lines, component migration, limb-length discrepancy, and heterotopic ossification.

Acetabular component evaluation was performed using the DeLee and Charnley classification, assessing radiolucent lines in Zones I, II, and III. Femoral component fixation and stability were evaluated using Gruen zones. Evidence of spot weld formation, trabecular continuity, and absence of progressive radiolucency were considered indicators of successful osteointegration.

Preoperative templating was performed for all patients to determine cup size, stem size, center of rotation, and anticipated neck cut level. Acetabular cup inclination and positioning were assessed according to standard arthroplasty principles.

Outcome Measures

The primary outcome was radiological evidence of implant stability and osteointegration at 6 months. Secondary outcomes included detection of radiolucent lines, component migration, loosening, limb-length discrepancy, and heterotopic ossification.

Statistical Analysis

Radiological findings were summarized using descriptive statistics. Categorical variables were presented as frequencies and percentages, whereas continuous measurements were expressed as mean \pm standard deviation.

Ethical Approval

Approval for the study was obtained from the Institutional Ethics Committee of Raipur Institute of Medical Sciences, Raipur. All participants provided written informed consent for clinical and radiological follow-up assessments.

RESULTS

Patient Characteristics

A total of 79 patients who underwent primary total hip replacement (THR) were included in the radiological analysis. All patients completed the scheduled radiographic follow-up evaluations at immediate postoperative, 3-month, and 6-month intervals.

Table 1: Baseline Characteristics of the Study Population (N = 79)

| Variable | Value |
|----------------------------|-------------------|
| Number of patients | 79 |
| Age (years), Mean \pm SD | 44.16 \pm 13.85 |
| Male, n (%) | 61 (77.2) |
| Female, n (%) | 18 (22.8) |

Radiological Assessment of Implant Stability

Serial radiographs obtained immediately after surgery and during follow-up demonstrated satisfactory positioning and stability of both acetabular and femoral components in the majority of patients. There was no radiographic evidence of clinically significant component migration, implant loosening, or osteolysis during the 6-month follow-up period.

Evidence of osteointegration was observed in most patients, as demonstrated by maintenance of component position, absence of progressive radiolucent lines, and preservation of implant stability on serial radiographs.

Acetabular Component Evaluation

Assessment of the acetabular component was performed using the DeLee and Charnley zonal classification. No radiolucent lines were observed in Zones I and II during follow-up. Radiolucency was identified in Zone III, corresponding to the non-weight-bearing region of the acetabular component, in 5 patients (6.3%).

Table 2. Radiological Findings Around the Acetabular Component

| Radiological Finding | Frequency (n) | Percentage (%) |
|---|---------------|----------------|
| No radiolucency in DeLee and Charnley Zone I | 79 | 100.0 |
| No radiolucency in DeLee and Charnley Zone II | 79 | 100.0 |
| Radiolucency in DeLee and Charnley Zone III | 5 | 6.3 |
| Component migration | 0 | 0.0 |
| Acetabular loosening | 0 | 0.0 |

Femoral Component Evaluation

Radiographic assessment of the femoral stem was performed using Gruen zonal analysis. Radiolucency around the femoral component was observed in Gruen Zone IV in 6 patients (7.5%). No progressive radiolucency, stem subsidence, or radiographic evidence of loosening was identified during follow-up.

Table 3. Radiological Findings Around the Femoral Component

| Radiological Finding | Frequency (n) | Percentage (%) |
|-------------------------------|---------------|----------------|
| Radiolucency in Gruen Zone IV | 6 | 7.5 |
| Stem subsidence | 0 | 0.0 |
| Femoral component loosening | 0 | 0.0 |
| Osteolysis | 0 | 0.0 |

Overall Radiological Outcome

Serial radiographic evaluation demonstrated satisfactory implant fixation and stability in the majority of patients. Limited radiolucent lines were observed around both acetabular and femoral components; however, these findings were not associated with clinical symptoms or evidence of implant instability. No cases of osteolysis, significant component migration, or radiographic failure were observed during the study period.

Table 4. Summary of Radiological Outcomes at 6 Months

| Outcome | Frequency (n) | Percentage (%) |
|---|---------------|----------------|
| Stable implant fixation | 74 | 93.7 |
| Acetabular radiolucency (DeLee and Charnley Zone III) | 5 | 6.3 |
| Femoral radiolucency (Gruen Zone IV) | 6 | 7.5 |
| Osteolysis | 0 | 0.0 |
| Component migration | 0 | 0.0 |
| Radiographic loosening | 0 | 0.0 |

Overall, radiological evaluation at 6 months demonstrated favorable implant positioning, satisfactory osteointegration, and maintenance of component stability following total hip replacement.

DISCUSSION

The findings of this prospective study underscore the radiological success and short-term stability of Total Hip Replacement in a rural and tribal population in Chhattisgarh. Our primary observation of 93.7% stable implant fixation at the six-month follow-up suggests that modern arthroplasty techniques and uncemented fixation provide reliable early outcomes, even when performed in resource-limited settings. This high rate of stability is consistent with recent literature from other rural Indian contexts; for instance, Jain et al. reported comparable clinical outcomes to international standards in a rural Maharashtra hospital, despite a younger demographic with a mean age of 40.32 years (20). Similarly, our cohort demonstrated a relatively young mean age of 44.16 years, highlighting the distinct demographic profile of hip pathology in India compared to Western registry data (5,20).

Radiological evaluation served as the primary tool for assessing component behavior in our study. Following the systematic guidelines established for postoperative radiographic interpretation, we utilized the DeLee and Charnley zones for the acetabulum and the Gruen zones for the femoral component (6,9,10). While the majority of patients exhibited no periprosthetic lucency, we identified radiolucent lines in DeLee and Charnley Zone III in 5 patients (6.3%) and Gruen Zone IV in 6 patients (7.5%). These findings were localized to non-weight-bearing regions and were not associated with clinical symptoms or component instability. According to Vanrusselt et al., such lucencies, when measuring less than 2 mm and bounded by a sclerotic margin, often indicate fibrous rather than bony ingrowth, which can still provide sufficient stability for the implant (6). The absence of progressive radiolucency, stem subsidence, or acetabular migration in our series further supports the conclusion that these early findings do not signify impending failure.

The clinical significance of early osteointegration cannot be overstated, as it is a critical determinant of long-term prosthesis survival (13,15). The evidence of spot welds and the preservation of implant positioning across our 79-patient cohort suggest successful biological fixation. This is particularly relevant for the tribal and rural population of Raipur, where patients often engage in demanding manual labor. Lakhotia and Agrawal noted that for low-income populations in India—including farmers and manual laborers—THR provides essential functional restoration that allows for a return to professional activity (18). The 0% rate of osteolysis and component migration observed in our study at six months aligns with the findings of Kadam et al., who reported 81% excellent results and adequate stability in a rural cohort using similar zonal assessment metrics (19).

Performing THR in resource-limited settings presents unique challenges, including variations in bone quality and limited access to long-term follow-up care. However, our results demonstrate that standardized surgical protocols, such as the posterior Moore approach used here, can achieve high success rates. The absence of radiographic failure in our study

suggests that the implants performed well in the immediate postoperative period, which is the most critical phase for establishing biological fixation (7,16).

Limitations

Despite the favorable outcomes observed, this study has several limitations. The follow-up period was limited to six months, which, while sufficient for assessing initial osteointegration and early stability, is inadequate for detecting late complications such as polyethylene wear or late aseptic loosening. Secondly, the sample size of 79 patients, though representative of our regional referral center, may limit the generalizability of the findings to the broader Indian population. Future studies with larger cohorts and multi-year follow-up intervals are required to confirm the long-term durability of these implants in the rural and tribal demographic of Central India.

CONCLUSION

The present study conducted at the Raipur Institute of Medical Sciences demonstrates that uncemented Total Hip Replacement using the posterior Moore approach is a highly effective intervention for patients in the rural and tribal regions of Chhattisgarh. Despite the challenges inherent in a resource-limited setting and a significantly younger patient demographic (mean age 44.16 years), the study achieved a 93.7% rate of stable implant fixation at the six-month follow-up. Radiological assessment confirmed successful early osteointegration across the 79-patient cohort, with a complete absence of major complications such as osteolysis or component migration.

While localized radiolucencies were identified in DeLee and Charnley Zone III (6.3%) and Gruen Zone IV (7.5%), these were clinically insignificant early findings that did not indicate impending failure or compromise implant stability (6). These results affirm that uncemented THR provides essential functional restoration for manual laborers and low-income groups, facilitating a return to professional activity and enhancing quality of life (18,19). However, while these early radiological outcomes are promising, long-term multi-year follow-up is necessary to confirm the enduring durability of these implants in the rural and tribal demographic of Central India.

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