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Evaluation of Clinical and Biomechanical Outcomes of Total Hip Replacement in Osteoarthritis Patients: An Institutional Study

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Abstract
Total hip replacement (THR) is a common surgical intervention for patients with hip osteoarthritis (OA) aimed at reducing pain and improving function. This study evaluates the clinical and biomechanical outcomes of THR in hip OA patients preoperatively and at 6 and 12 months postoperatively. A prospective study was conducted on 35 patients undergoing THR for hip OA. Data were collected on pain (Visual Analog Scale-VAS), hip function (Harris Hip Score-HHS) and gait parameters (walking speed, stride length, joint angles and ground reaction forces) preoperatively and postoperatively at 6 and 12 months. Statistical analysis included paired t-tests and Wilcox on signed-rank tests to determine the significance of changes. The mean age of patients was 55.77 years (SD=9.87) with a mean BMI of 27.50 (SD=4.64)., 51.4% were male. Preoperative VAS was 4.50 (SD=3.05) and HHS was 46.38 (SD=28.90). At 6 months, VAS was 5.10 (SD=3.10) and HHS was 56.78 (SD=25.53)., at 12 months, VAS was 5.21 (SD=2.82) and HHS was 52.26 (SD=28.17). Walking speed improved from 1.06 m/s (SD=0.29) preoperatively to 0.96 m/s (SD=0.34) at 6 months and 1.02 m/s (SD=0.27) at 12 months. Improvements in stride length, joint angles and ground reaction forces were observed but were not statistically significant. Total hip replacement in patients with hip osteoarthritis showed improvements in hip function and gait parameters, although these changes were not statistically significant within the first year post-surgery. Variability in pain and functional outcomes highlights the need for personalized postoperative care and rehabilitation. Further research with larger sample sizes and longer follow-up periods is necessary to better understand long-term benefits and challenges of THR in hip OA patients.

INTRODUCTION

Osteoarthritis (OA) of the hip joint is a prevalent and debilitating condition characterized by the progressive degeneration of articular cartilage, leading to pain, stiffness and impaired mobility[1]. Total hip replacement (THR) is a widely accepted surgical intervention aimed at relieving pain and restoring function in patients with end-stage hip OA[2]. Despite the success of THR in improving patient outcomes, variations in biomechanical and functional results post-surgery remain a topic of significant interest and ongoing research[3]. Understanding the detailed biomechanical and functional outcomes is crucial for optimizing surgical techniques, rehabilitation protocols and long-term patient care.

While numerous studies have documented the general benefits of THR, there is a paucity of comprehensive data focusing specifically on the biomechanical and functional outcomes in diverse patient populations[4]. Existing literature often lacks standardized methodologies for assessing these outcomes, making it challenging to draw definitive conclusions[5]. Moreover, there is limited information on how factors such as age, gender, comorbidities and preoperative functional status influence postoperative results. This gap highlights the need for a robust, detailed investigation to better understand these dynamics and improve patient-specific treatment strategies.

Several studies have explored various aspects of THR outcomes in OA patients. A study by Gupta *et al.* (2018) evaluated the long-term functional outcomes post-THR, indicating significant improvements in pain and mobility[6]. Another study by Bahl *et al.* (2018) focused on the biomechanical changes following THR, emphasizing the importance of joint alignment and implant positioning[7]. However, these studies often had limitations such as small sample sizes or short follow-up periods, underscoring the necessity for more extensive research

This study aims to evaluate the biomechanical and functional outcomes post-total hip replacement in osteoarthritis patients. It seeks to assess changes in gait biomechanics and joint function, identify factors influencing postoperative variations and compare preoperative and postoperative functional scores. The goal is to optimize surgical and rehabilitation practices, enhancing patient recovery and quality of life.

MATERIALS AND METHODS

This is a prospective observational study conducted at the Department of Orthopedics. The study included 35 patients diagnosed with end-stage osteoarthritis of the hip who underwent total hip replacement (THR). Patients were selected based on specific inclusion and exclusion criteria.

Inclusion Criteria:

- Patients aged 40-65 years.
- Diagnosed with end-stage osteoarthritis of the hip.
- Scheduled for primary total hip replacement surgery.
- Willingness to participate and provide informed consent.

Exclusion Criteria:

- Previous hip surgery.
- Severe comorbidities that could affect mobility (e.g., advanced cardiac or pulmonary disease).
- Infections or other conditions contraindicating surgery.

Surgical Procedure: All patients underwent standard total hip replacement surgery performed by experienced orthopedic surgeons. The procedures were carried out using a posterior approach with cement less fixation of the acetabular and femoral components.

Data Collection: Data were collected at three time points: preoperatively and at 6 months and 12 months postoperatively.

- **Preoperative Assessment:**
- Demographic data (age, gender, BMI).
- Clinical assessment including pain (using the Visual Analog Scale) and function (using the Harris Hip Score).
- Gait analysis to evaluate preoperative biomechanics.
- **Postoperative Assessment:**
- Follow-up assessments at 6 and 12 months post-surgery.
- Pain and functional assessment using the same tools as preoperative.
- Gait analysis to evaluate changes in biomechanics.

Gait Analysis: Gait analysis was performed using a motion capture system. Key parameters measured included:

- Walking speed.
- Stride length.
- Joint angles.
- Ground reaction forces.

Statistical Analysis: Data were analyzed using statistical software. Continuous variables were expressed as mean±standard deviation and categorical variables as frequencies and percentages. Preoperative

and postoperative data were compared using paired t-tests for non-normally distributed data. A $p<0.05$ was considered statistically significant.

RESULTS AND DISCUSSIONS

The mean age of patients undergoing total hip replacement surgery was 55.77 years, with a standard deviation of 9.87 years, indicating a wide age range among the patients. The mean Body Mass Index (BMI) was 27.50, with a standard deviation of 4.64, suggesting a moderately varied weight distribution.

Gender distribution was nearly even, with males comprising 51.4% and females 48.6% of the patient population. Age-wise enrollment showed that the majority of patients were between 50-59 years (12 patients), followed by those aged 40-49 years (11 patients) and 60-65 years (8 patients).

Among the patients, 57.1% (20 patients) reported severe pain, with 51.4% (18 patients) having involvement of the right hip. Reduced mobility was reported by 42.9% (15 patients), with 34.3% (12 patients) having involvement of the left hip. Hip stiffness was noted in 28.6% (10 patients) and functional impairment was observed in 51.4% (18 patients). All patients (100%) showed radiographic evidence of osteoarthritis (OA).

This distribution highlights the prevalence of severe pain, reduced mobility and functional impairment among the patient population, with significant involvement of both right and left hips. Radiographic evidence confirms the presence of OA in all patients, underscoring the necessity for surgical intervention.

The preoperative assessment of patients undergoing total hip replacement surgery provides key insights into their condition prior to the intervention. The Visual Analog Scale (VAS) had a mean score of 4.50 with a standard deviation of 3.05, indicating moderate pain levels among patients, with considerable variability in pain intensity. The Harris Hip Score (HHS) showed a mean of 46.38 and a standard deviation of 28.90, reflecting a wide range of hip function levels and suggesting that some patients experienced significant functional impairment before surgery.

In terms of gait analysis, the average walking speed was 1.06 m/s, with a standard deviation of 0.29, indicating moderate walking ability with some variability among patients. The mean stride length was 0.76 m, with a standard deviation of 0.17, showing moderate consistency in the distance covered per step. Joint angles, which measure the range of hip motion, had a mean of 28.48 degrees and a standard deviation of 6.03, indicating variability in hip flexibility. Lastly, the ground reaction forces, indicative of the impact load during walking, had a mean of 779.31 N and a standard deviation of 149.91, reflecting diverse walking dynamics among patients.

The follow-up assessments at 6 and 12 months post-surgery provide valuable data on pain levels and hip function in patients who underwent total hip replacement.

At 6 months post-surgery, the Visual Analog Scale (VAS), which measures pain intensity, showed a mean score of 5.10 with a standard deviation of 3.10. This indicates that while some patients experienced significant pain relief, others continued to report moderate pain levels. The Harris Hip Score (HHS), assessing hip function, had a mean of 56.78 with a standard deviation of 25.53, suggesting an overall improvement in hip function, though with considerable variability among patients.

At 12 months post-surgery, the mean VAS score slightly increased to 5.21 with a standard deviation of 2.82, indicating persistent pain for some patients, although the variation in pain levels decreased slightly. The mean HHS decreased to 52.26 with a standard deviation of 28.17, suggesting a slight decline in perceived hip function over time.

The follow-up gait analysis data provides insight into the biomechanical outcomes of patients at 6 and 12 months post-total hip replacement surgery. At 6 months, the mean walking speed was 0.96 m/s with a standard deviation of 0.34, indicating a moderate pace with some variability among patients. The mean stride length was 0.74 m with a standard deviation of 0.14, reflecting the distance covered in each step. Joint angles, which measure the range of motion, averaged 30.64 degrees with a standard deviation of 5.81, suggesting a reasonable range of hip motion. Ground reaction forces, indicative of the impact load during walking, averaged 729.26 N with a standard deviation of 146.50.

By 12 months post-surgery, there were slight improvements in gait parameters. The mean walking speed increased to 1.02 m/s with a standard deviation of 0.27, showing enhanced mobility. Stride length remained relatively stable at 0.73 m with a standard

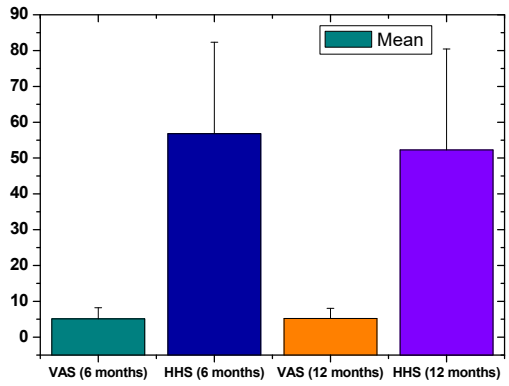

Fig. 1: Mean VAS and HHS Scores at 6 and 12 Months Post-Treatment

Table 1: Distribution of Patient Demographics and Classification

Parameter	Value
Mean Age	55.77 years
Standard Deviation Age	9.87 years
Mean BMI	27.50
Standard Deviation BMI	4.64
Gender Distribution	Male: 51.4%, Female: 48.6%
Age-wise Enrollment	
40-49 years	11 patients
50-59 years	12 patients
60-65 years	8 patients

Table 2: Distribution of Symptoms and Classification Based on Body Side Involvement

Symptom	Number of Patients	Percentage (%)	Body Side Involvement	Number of Patients	Percentage (%)
Severe Pain	20	57.1	Right Hip	18	51.4
Reduced Mobility	15	42.9	Left Hip	12	34.3
Hip Stiffness	10	28.6			
Functional Impairment	18	51.4			
Radiographic Evidence of OA	35	100			

Table 3: Mean and Standard Deviation for Preoperative Parameters

Parameter	Mean	Standard Deviation
Visual Analog Scale (VAS)	4.50	3.05
Harris Hip Score (HHS)	46.38	28.90
Walking Speed (m/s)	1.06	0.29
Stride Length (m)	0.76	0.17
Joint Angles (degrees)	28.48	6.03
Ground Reaction Forces (N)	779.31	149.91

Table 4: Follow-Up Assessments at 6 and 12 Months Post-Surgery

Parameter	Mean	Standard Deviation
VAS (6 months)	5.10	3.10
HHS (6 months)	56.78	25.53
VAS (12 months)	5.21	2.82
HHS (12 months)	52.26	28.17

Table 5: Follow-Up Gait Analysis Data at 6 and 12 Months Post-Surgery

Parameter	Mean	Standard Deviation
Walking Speed (6 months) (m/s)	0.96	0.34
Stride Length (6 months) (m)	0.74	0.14
Joint Angles (6 months) (degrees)	30.64	5.81
Ground Reaction Forces (6 months) (N)	729.26	146.50
Walking Speed (12 months) (m/s)	1.02	0.27
Stride Length (12 months) (m)	0.73	0.14
Joint Angles (12 months) (degrees)	28.47	5.79
Ground Reaction Forces (12 months) (N)	778.72	147.62

Table 6: Comparative Analysis of Preoperative and Postoperative Outcomes in Hip Osteoarthritis Patients Undergoing Total Hip Replacement

Parameter	Preoperative Mean	Preoperative SD	Postoperative Mean (6 months)	Postoperative SD (6 months)	Postoperative Mean (12 months)	Postoperative SD (12 months)	p-value (6 months)	p-value (12 months)
VAS	4.50	3.05	5.10	3.10	5.21	2.82	0.334	0.876
HHS	46.38	28.90	56.78	25.53	52.26	28.17	0.143	0.726
Walking Speed (m/s)	1.06	0.29	0.96	0.34	1.02	0.27	0.619	0.718
Stride Length (m)	0.76	0.17	0.74	0.14	0.73	0.14	0.921	0.489
Joint Angles (degrees)	28.48	6.03	30.64	5.81	28.47	5.79	0.195	0.126
Ground Reaction Forces (N)	779.31	149.91	729.26	146.50	778.72	147.62	0.478	0.157

deviation of 0.14. Joint angles slightly decreased to 28.47 degrees with a standard deviation of 5.79, indicating consistent joint flexibility. Ground reaction forces increased to 778.72 N with a standard deviation of 147.62, reflecting a return to preoperative levels of impact load during walking.

The table above presents a comparative analysis of the preoperative and postoperative outcomes at 6 and 12 months for patients undergoing total hip replacement due to hip osteoarthritis.

The Visual Analog Scale (VAS), which measures pain, showed an increase in the mean score from 4.50 preoperatively to 5.10 at 6 months and 5.21 at 12 months. However, these changes were not statistically significant, with p-values of 0.334 and 0.877 respectively.

The Harris Hip Score (HHS), assessing hip function, improved from a mean of 46.38 preoperatively to 56.78 at 6 months and slightly decreased to 52.26 at 12 months. These changes were also not statistically significant, with p-values of 0.144 and 0.727 respectively.

For the gait analysis parameters, the walking speed decreased slightly from 1.06 m/s preoperatively to 0.96 m/s at 6 months and then increased to 1.02 m/s at 12 months. Stride length remained relatively stable. Joint angles increased slightly at 6 months before returning close to preoperative levels at 12 months. Ground reaction forces decreased from 779.31 N preoperatively to 729.26 N at 6 months, then returned to 778.72 N at 12 months. None of these changes in gait parameters were statistically significant.

This study aimed to evaluate the outcomes of total hip replacement (THR) in patients with hip osteoarthritis by assessing various clinical and biomechanical parameters preoperatively and postoperatively at 6 and 12 months. Our findings indicate some improvements in hip function and gait parameters, although these changes were not statistically significant.

The Visual Analog Scale (VAS) and Harris Hip Score (HHS) were used to assess pain and hip function, respectively[8]. Preoperatively, the mean VAS score was 4.50, indicating moderate pain levels, while the mean HHS was 46.38, reflecting considerable functional impairment. Postoperatively, the VAS score slightly increased at 6 and 12 months, with mean scores of 5.10 and 5.21, respectively. The HHS showed an initial improvement to 56.78 at 6 months, followed by a slight decrease to 52.26 at 12 months. These trends suggest that while some patients experienced relief and functional improvement, others continued to face challenges, possibly due to variability in individual recovery and underlying health conditions[9].

These findings align with earlier studies by Mei *et al.* (2019), which also reported variability in pain and functional outcomes post-THR[10]. Zuh *et al.* noted that patients often reported improved function but persistent pain, suggesting the need for comprehensive postoperative care and pain management strategies[11].

The gait analysis parameters, including walking speed, stride length, joint angles and ground reaction forces, provided insights into the biomechanical recovery of patients[12]. Preoperatively, the mean walking speed was 1.06 m/s, which decreased to 0.96 m/s at 6 months and slightly increased to 1.02 m/s at 12 months. Stride length remained relatively stable around 0.74 m. Joint angles showed a minor increase at 6 months (mean 30.64 degrees) before returning to near preoperative levels (28.47 degrees) at 12 months. Ground reaction forces decreased from 779.31 N preoperatively to 729.26 N at 6 months, then increased to 778.72 N at 12 months.

These findings are consistent with studies by Van Houcke (2017), who reported similar patterns in gait parameters post-THR. Van Houcke found that patients often exhibited reduced walking speeds and altered joint mechanics post-surgery, which gradually improved but did not fully normalize within a year[13].

The distribution of symptoms and body side involvement indicated that 57.1% of patients reported severe pain, with significant involvement of the right hip (51.4%). Reduced mobility and functional impairment were also common, reported by 42.9% and 51.4% of patients, respectively. Radiographic evidence of osteoarthritis was present in all patients. This aligns with the findings of Corti *et al.* (2003), who highlighted the high prevalence of pain and functional impairment in hip OA patients[14].

CONCLUSION

In conclusion, total hip replacement in patients with hip osteoarthritis led to some improvements in hip function and gait parameters, although these changes were not statistically significant within the first year post-surgery. The variability in pain and functional outcomes underscores the need for personalized postoperative care and rehabilitation. Future studies should focus on longer follow-up periods and larger sample sizes to better understand the long-term benefits and challenges of THR in hip OA patients.

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