

Original Research Article

GAIT ANALYSIS THROUGH FOOT PRESSURE MAPPING IN PATIENT OF ARTHRITIC HIP - PRE AND POST TOTAL HIP ARTHROPLASTY

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ABSTRACT

Background: Hip arthritis produces pain, altered biomechanics, compensatory unloading of the affected limb, and asymmetrical plantar pressure distribution. Total Hip Replacement (THR) aims to restore hip mechanics, improve weight-bearing, and normalize gait. Foot pressure mapping provides an objective method for evaluating plantar pressure distribution and gait recovery before and after THR. The objective is to evaluate the change in foot pressure mapping in patients suffering from primary osteoarthritis hip undergoing unilateral Total Hip Replacement by comparing pre-operative and post-operative parameters, and to evaluate changes in gait parameters following operative intervention.

Materials and Methods: This prospective randomised study included 60 patients diagnosed with arthritis of the hip undergoing unilateral Total Hip Replacement. Pre-operative assessment and post-operative assessment at 3 weeks, 6 weeks, and 12 weeks were performed using Harris Hip Score and an embedded foot pressure mapping platform (Stepp Test and Gait Analysis System). Plantar pressure parameters and gait parameters were analysed using IBM SPSS Statistics, with repeated measures ANOVA where appropriate.

Results: The mean age of the study population was 61.33 ± 7.26 years. Males were 29 (48.33%) and females were 31 (51.67%). Left-sided procedures were performed in 33 patients (55.00%) and right-sided procedures in 27 patients (45.00%). Harris Hip Score showed statistically highly significant improvement across follow-up intervals, $F(3, 177) = 4712.47$, $p < 0.001$. Plantar pressure mapping demonstrated progressive reduction in left-right deviation, and gait parameters including cadence, velocity, heel contact time, and stance time improved over follow-up.

Conclusion: Unilateral Total Hip Replacement produced statistically significant improvement in functional outcome, plantar pressure symmetry, and gait parameters. Foot pressure mapping is a sensitive and objective tool for evaluating post-operative biomechanical recovery and may be used alongside functional scoring and radiographic assessment.

Keywords: Hip arthritis, Total Hip Replacement, Total Hip Arthroplasty, plantar pressure, foot pressure mapping, gait analysis, Harris Hip Score, biomechanical recovery.

INTRODUCTION

Arthritis of the hip is a chronic degenerative disorder characterized by progressive deterioration of articular cartilage, subchondral bone structural changes,

osteophyte formation, and synovial inflammation of varying degree. The disease process alters the biomechanical efficiency of the hip as a load-bearing ball-and-socket joint and leads to pain, stiffness, and progressive functional limitation.^[1,2]

As the disease progresses, the hip joint loses congruity and the distribution of mechanical load becomes abnormal. Pain from subchondral bone and inflamed synovium produces reflex inhibition of periarticular muscles, especially the hip abductors.^[3] The resulting muscle weakness changes joint reaction forces and disrupts normal gait mechanics. In unilateral disease, patients commonly demonstrate protective offloading of the affected limb, which can be assessed by reduced plantar pressure during stance and increased loading of the opposite extremity.^[1,4]

Total Hip Replacement is recommended for end-stage hip arthritis when persistent pain, functional impairment, and radiographic destruction continue despite conservative management. The procedure replaces the diseased acetabular and femoral articular surfaces with prosthetic components and aims to restore joint congruity, femoral offset, leg length, and the hip centre of rotation.^[5]

Although pain relief and functional improvement after THR are well recognized, restoration of symmetrical gait and plantar pressure distribution may be gradual. Clinical scores and radiographic parameters alone may not fully capture dynamic biomechanical recovery. Objective gait analysis and foot pressure mapping allow quantitative assessment of weight-bearing symmetry, plantar pressure redistribution, contact time, stance time, and gait progression.^[6,7]

Plantar pressure mapping is a quantitative biomechanical method that measures force distribution between the plantar surface of the foot and the ground during stance and gait. In hip pathology, altered proximal joint mechanics are reflected distally as measurable changes in plantar pressure distribution. Serial assessment before and after THR may therefore provide useful information regarding post-operative recovery and rehabilitation needs.

The present study was undertaken to evaluate changes in foot pressure mapping and gait parameters in patients with arthritic hip undergoing unilateral Total Hip Replacement, comparing pre-operative parameters with findings at 3 weeks, 6 weeks, and 12 weeks post-operatively.

MATERIALS AND METHODS

Study Design: Prospective randomised study.

Place of Study: Department of Orthopaedics, N.S.C.B. Subharti Medical College and Chhatrapati Shivaji Subharti Hospital, Meerut.

Study Period: The study was conducted over a period of two years.

Study Population: Patients diagnosed with primary arthritis of the hip and planned for unilateral Total Hip Replacement during the study period, fulfilling inclusion and exclusion criteria.

Sample Size: 60 patients.

Inclusion Criteria

- No history of previous surgery in the hip.

- Ability to stand independently for at least three minutes.
- Age of subject 54 to 69.

Exclusion Criteria

- Asymptomatic individuals.
- Presence of systemic diseases that may affect stance or postural control capability, such as neurological disorders.
- Congenital anomalies of the hip.

Methodology: Patients suffering from arthritis of the hip due to any cause, diagnosed by a consultant orthopaedic surgeon, were screened according to the inclusion and exclusion criteria. Eligible patients who provided written informed consent were enrolled in the study.

Clinical and radiological assessment: A detailed clinical evaluation was performed pre-operatively. Functional assessment was carried out using the Harris Hip Score questionnaire. Baseline radiological evaluation included X-ray pelvis.

Foot pressure mapping and gait analysis: Pre-operative plantar pressure assessment and gait analysis were performed using an embedded foot pressure mapping platform (Stepp Test and Gait Analysis System). Patients were instructed to walk barefoot over the platform at a self-selected comfortable speed under standardized conditions. Variables obtained from the foot pressure data were recorded and documented for analysis.

Operative procedure and follow-up: All patients underwent unilateral Total Hip Replacement of the affected side as per standard institutional surgical protocol. Post-operative evaluation was conducted at 3 weeks, 6 weeks, and 12 weeks. At each follow-up visit, patients underwent clinical assessment, Harris Hip Score evaluation, gait analysis, and foot pressure mapping using the same standardized protocol as pre-operative assessment.

Post-operative Rehabilitation: Post-operative rehabilitation was initiated according to institutional protocol. The operated limb was maintained in neutral alignment with appropriate positioning using pillows between the lower limbs to prevent excessive adduction. A post-operative X-ray pelvis with both hips was obtained to assess implant positioning. Standard physiotherapy including range of motion exercises, abductor strengthening, and gait training was administered.

Statistical Analysis: Collected data were entered into IBM SPSS Statistics. Continuous variables were expressed as mean and standard deviation, while categorical variables were expressed as frequency and percentage. Pre-operative and post-operative values were compared using paired statistical tests. For comparison across multiple follow-up intervals, repeated measures ANOVA was applied. A p-value of less than 0.05 was considered statistically significant.

RESULTS

The present prospective study involved 60 patients diagnosed with arthritis of the hip undergoing unilateral Total Hip Replacement. The mean age of the study population was 61.33 ± 7.26 years. Among the 60 patients, 29 patients (48.33%) were male and 31 patients (51.67%) were female. Left-sided procedures were performed in 33 patients (55.00%), while right-sided procedures were performed in 27 patients (45.00%).

Functional outcome: Harris Hip Score

Harris Hip Score improved progressively from the pre-operative assessment to 12 weeks post-operatively. Repeated measures ANOVA showed statistically highly significant improvement across time intervals, $F(3, 177) = 4712.47$, $p < 0.001$.

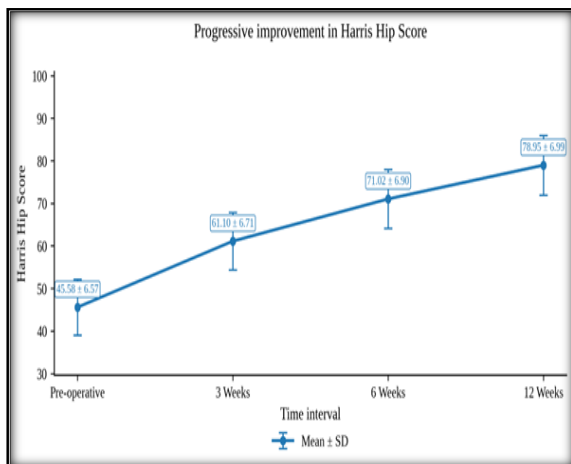


Figure 1: Line graph illustrating progressive improvement in mean Harris Hip Score from pre-operative status to 12 weeks post-operatively.

Plantar pressure parameters: Maximum, peak, and average plantar pressure values demonstrated progressive restoration toward symmetrical loading. Left-right deviation moved progressively toward zero, indicating restoration of balanced weight distribution after surgery.

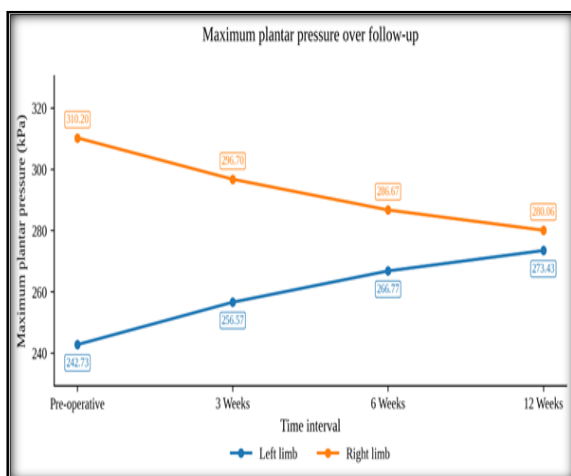


Figure 2A: Line graph demonstrating progressive normalization of maximum plantar pressure between left and right limbs from pre-operative status to 12 weeks post-operatively.

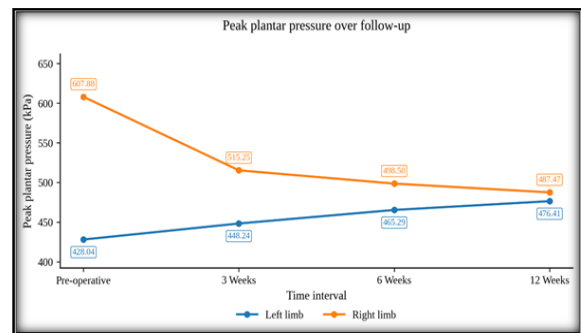


Figure 2B: Line graph showing progressive convergence of peak plantar pressure values between limbs over successive follow-up intervals.

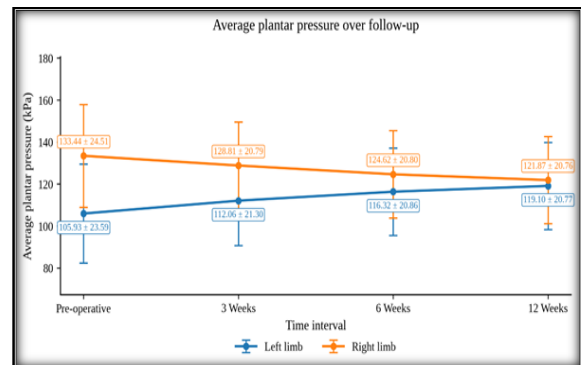


Figure 2C: Line graph showing progressive normalization of average plantar pressure between left and right limbs from pre-operative status to 12 weeks post-operatively.

For average plantar pressure, repeated measures ANOVA showed statistically highly significant changes for the operated limb, $F(3,177) = 233.56$, $p < 0.001$, the opposite limb, $F(3,177) = 93.11$, $p < 0.001$, and LR deviation, $F(3,177) = 571.93$, $p < 0.001$.

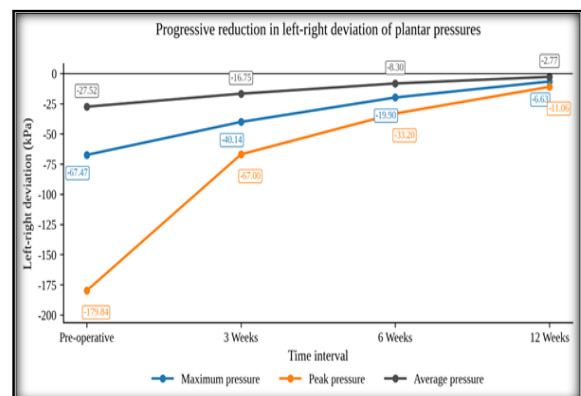


Figure 2D: Line graph illustrating progressive reduction in left-right deviation for maximum, peak, and average plantar pressure, approaching symmetry by 12 weeks post-operatively.

Gait parameters: Cadence, velocity, heel contact time, and stance time showed progressive improvement across follow-up intervals, indicating improved walking rhythm, forward progression, heel strike mechanics, and stance stability. The differences were statistically significant ($p < 0.01$).

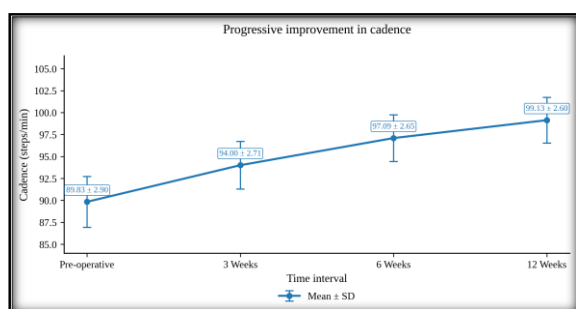


Figure 3A: Line graph showing progressive improvement in cadence from pre-operative status to 12 weeks post-operatively.

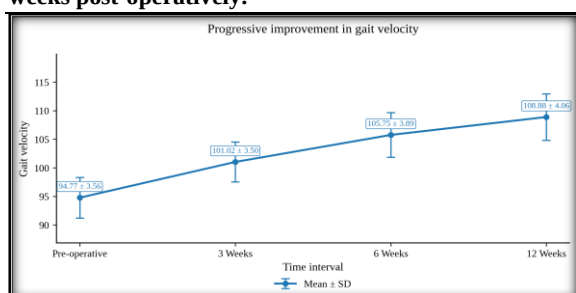


Figure 3B: Line graph illustrating gradual increase in gait velocity across follow-up intervals, indicating progressive functional recovery.

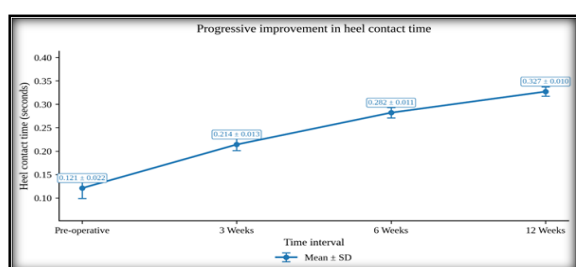


Figure 3C: Line graph demonstrating progressive normalization of heel contact time over successive follow-up intervals.

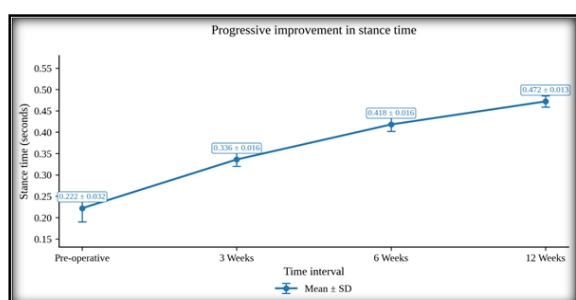


Figure 3D: Line graph showing progressive increase in stance time across follow-up intervals, reflecting improved gait stability post-operatively.

DISCUSSION

The present prospective randomised study evaluated the change in foot pressure mapping and gait parameters in patients with arthritic hip undergoing unilateral Total Hip Replacement. The results demonstrated progressive improvement in functional outcome, plantar pressure symmetry, and gait parameters across the post-operative follow-up period.

The study population consisted of patients in the older age group, which is consistent with the degenerative nature of hip arthritis. The near-equal sex distribution and mild predominance of left-sided procedures provided a balanced cohort for evaluating functional and biomechanical outcomes.

Harris Hip Score improved significantly after surgery, indicating reduction in pain and improvement in daily functional ability. This improvement supports the clinical effectiveness of Total Hip Replacement in restoring hip function in patients with arthritic hip.

Pre-operative plantar pressure findings demonstrated marked asymmetry, reflecting protective unloading of the affected limb and compensatory overloading of the contralateral limb. These findings support the biomechanical concept that unilateral hip arthritis alters distal loading patterns through the lower limb kinetic chain.^[1,4]

After surgery, plantar pressure distribution improved progressively, with left-right deviation moving toward zero by the 12-week follow-up. This pattern indicates gradual restoration of symmetrical loading and confirms that THR produces measurable distal biomechanical changes at the foot-ground interface. The present findings are consistent with Gimunová et al., who reported changes in plantar pressure, contact area, and contact time symmetry before and after unilateral total hip arthroplasty.^[2] Miura et al. also demonstrated altered plantar pressure distribution in patients with hip osteoarthritis and highlighted the relationship between hip pathology and plantar loading.^[8] Bahadori et al. emphasized the current and future importance of gait analysis in evaluating hip replacement outcomes, supporting objective biomechanical assessment beyond clinical scores alone.^[6]

Gait parameters also improved progressively after THR, reflecting improved rhythm, forward progression, heel strike mechanics, limb loading confidence, and stance stability. These changes indicate that THR contributes not only to pain relief but also to restoration of dynamic functional mobility.

Although the improvements were statistically significant, minor asymmetry persisted at 12 weeks, suggesting that structural correction and pain relief occur earlier, while complete neuromuscular adaptation and symmetrical gait restoration may require longer follow-up and continued rehabilitation. Persistent subtle gait deviations after THR have been described in the literature and support the need for objective monitoring.^[2,6]

The study supports the role of plantar pressure mapping as an objective adjunct for evaluating post-operative biomechanical recovery after unilateral THR. When combined with Harris Hip Score and radiographic assessment, dynamic gait analysis provides a broader evaluation of pain relief, functional recovery, implant-related biomechanical restoration, and real-time weight-bearing symmetry.

CONCLUSION

The present study concludes that unilateral Total Hip Replacement in patients with hip arthritis produces statistically highly significant improvement in functional outcome, anatomical reconstruction, and biomechanical performance.

Pre-operatively, patients demonstrated marked asymmetry in plantar pressure and gait parameters due to compensatory unloading of the affected limb. Following surgical intervention, progressive restoration of balanced weight-bearing was observed, with substantial reduction in left-right deviation by 12 weeks. Gait parameters improved consistently, reflecting enhanced confidence in limb loading and improved functional mobility.

Although minor asymmetries persisted at 12 weeks, the overall biomechanical recovery was statistically robust and clinically meaningful. The findings highlight that Total Hip Replacement not only relieves pain but also significantly restores mechanical alignment and functional gait patterns. However, complete normalization of neuromuscular adaptation may require longer follow-up and continued rehabilitation.

The study supports the use of plantar pressure mapping as a sensitive and objective tool for evaluating post-operative biomechanical recovery. Integration of functional scoring, radiographic assessment, and dynamic gait analysis provides a comprehensive evaluation framework for patients undergoing unilateral THR.

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