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# The Effect of Total Hip Arthroplasty Surgical Approach on Postoperative Gait Mechanics

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**Abstract:** Surgical approach for total hip arthroplasty (THA) is determined by clinician preference from limited prospective data. This study aimed to examine the effect of surgical approach (direct lateral, posterior, and anterolateral) on 6-week postoperative gait mechanics. Thirty-five patients (direct lateral, 8; posterior, 12; anterolateral, 15) were tested preoperatively and 6 weeks after THA. Patients underwent a gait analysis at a self-selected walking speed. A 2-way analysis of variance was used for analysis. Stride length, step length, peak hip extension, and walking speed increased after THA. The 3 surgical approach variables were not significantly different for any of the study variables after THA. All patients showed some increase in selected variables after THA regardless of surgical approach. In this study, surgical approach did not appear to significantly influence the early postoperative gait mechanics that were quantified. **Keywords:** gait analysis, total hip arthroplasty, surgical approach.


An estimated 2.5% of the population older than 40 years receives a total hip arthroplasty (THA) typically as a result of trauma or degenerative joint disease [1]. Patients usually present with reduced pain, improved function, and improved gait after THA surgery. Some common adverse effects and complications after THA include hip dislocation, hip musculature weakness, a Trendelenburg gait pattern, and the presence of a limp during gait [2-6]. It is hypothesized that some of these complications may be associated with the different types of surgical approaches used for THA.

A number of studies have assessed gait changes in patients after a THA [7-18]. Typically, after a THA, patients exhibit increased range of motion and improved symmetry of joint motion during gait, whereas changes in gait temporospatial parameters are less consistent [14,17,18]. Cross-sectional studies after the THA surgery have suggested that a posterior (P) surgical approach is most successful in improving hip joint symmetry in comparison with an anterior and anterolateral (AL) approach; however, the differences in these studies could be attributed to presurgical differences [8,11,19,20]. Studies examining the longitudinal effect of the different surgical approaches for THA on gait mechanics have reported minimal differences between techniques in restoring symmetry in ground reaction forces (GRFs), temporospatial parameters, or hip torques when factoring in presurgical values [10,12,13]. However, little evidence exists reporting the changes that occur locally at the hip joint during gait when individuals are recovering from different THA surgical approaches.

In summary, a number of studies have examined changes in gait after THA; however, there are limited prospective comparisons of hip mechanics during gait between different types of surgical approaches for THA. Therefore, the purpose of this study was to examine changes in gait mechanics between 3 common surgical approaches to the hip (AL, direct lateral [DL], and P) for THA. The changes in gait between the time before surgery and 6 weeks after the surgery were examined. It was expected that all subjects would demonstrate a significant improvement in gait from the preoperative time point to the 6-week postoperative time point and that no significant differences would exist between the surgical approaches.

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## Materials and Methods

A total of 35 subjects (8 DL, 12 P, and 15 AL) participated in this study. The surgical approach groups had equal numbers of men and women, except for the AL approach group in which there were 7 men and 8 women. To participate, all subjects needed to be older than 35 years and be scheduled to have a THA within the next month. Patients with contralateral hip pain, diagnosis of contralateral joint degeneration, previous total joint arthroplasty in the lower extremity, or any history of neurologic disorders were excluded from this study. Subjects were recruited from three orthopedic clinics at the university, and consecutive patients who met the inclusion criteria and were willing to consent were enrolled for testing. Each subject read and signed an informed consent that had been approved by the medical center's institutional review board. After completion of the consent form, subjects were asked to change into form-fitting shorts for the remainder of testing.

The 3 surgical approaches that were examined were the DL or modified Hardinge, the standard P, and the AL or modified Watson-Jones approach.

In the DL group, the anterior one third of the gluteus medius from the origin of the vastus lateralis going proximally was detached and retracted anteriorly. The anterior one third to one half of the gluteus minimus was then split in line with the femoral neck, and a capsular window was excised. The anterior inferior hip ligaments were released to allow anterior hip dislocation. After implants were placed, each layer (gluteus minimus, gluteus medius, and fascia) was repaired anatomically with multiple nonabsorbable sutures. In the P group, the short external rotators and capsule were taken down directly off the posterior aspect of the femur. The extent of muscle release distally in this study group included partial release of the quadratus in some cases but no release of the gluteal sling. The inferior capsule was in most cases released to allow for idealized exposure for acetabular preparation. In the AL group, an incision was made through the skin on the line from the anterior superior iliac spine to the trochanter after which the interval between the anterior portion of the gluteus musculature and the tensor fascia was developed. After anterior capsulotomy, the acetabulum was prepared with hip abducted and externally rotated. The femur was prepared with the leg in extension and external rotation [21].

For the walking tests, subjects were asked to walk barefoot to avoid changes in the GRFs because of footwear. Reflective markers were then placed by a single tester at 39 anatomical landmarks [22,23]: sacrum (L5-S1), bilaterally on the acromioclavicular joint, lateral epicondyle, midpoint between the radial and ulnar styloids, anterior superior iliac spine, posterior superior iliac spine, greater trochanter, iliac crest, thigh, lateral knee (femoral condyle), shank, lateral malleolus, posterior superior heel, the second webspace (toes) in line vertically with the superior heel marker, posterior inferior heel, lateral heel, medial malleolus, medial femoral condyle, first metatarsal head, and fifth metatarsal head (Fig. 1). Subjects were then asked to stand within the capture volume in the anatomical position to record a static standing trial. The markers were recorded using an 8 camera real-time motion capture system (Motion Analysis Inc, Santa Rosa, Calif) sampling at 120 Hz. After the standing trial, the medial malleolus and medial femoral condyle, iliac crest, first metatarsal and fifth metatarsal markers were removed. Subjects were asked to walk at a self-selected comfortable walking speed during each of the walking trials. The dynamic assessment consisted of 7 walking trials along a 40-m walkway. Ground reaction force data were collected using 4 AMTI force plates that were embedded in the walkway (AMTI Inc, Watertown, Mass), sampling at 1200 Hz. This same procedure was repeated 6 weeks after THA.

Height, weight, age, Harris Hip Score, and surgical approach were recorded for each patient. The following study variables were analyzed to determine if any significant differences existed between the surgical approach groups or between the preoperative and 6-week postoperative time points: stance time, step length, stride length, step time, swing time, walking speed, peak vertical GRF, peak hip flexion angle, peak hip extension angle, hip flexion/extension angle at heel strike, peak hip abduction (ABD) angle and hip ABD/adduction (ADD) angle at heel strike. Step length is the distance between the heel of one foot and the heel of the contralateral foot during the double-support phase of gait. Stride length is the distance between the heel strike of one foot and the next heel strike of the same foot. Both step length and stride length were normalized to the subject's standing height. The temporal parameters that were obtained were stance time, step time, and swing time. Stance time is the time from heel strike on one foot to toe off of the same foot. Step time is the time from heel of one foot and the heel of the contralateral foot during the double support phase of gait. Finally, swing time is the time that elapses when the foot is not on the ground, from toe off of one foot to heel strike of the same foot. Each of these variables was normalized as a percentage of the gait cycle. The GRF data were normalized to each subject's body weight.

To better understand the potential differences in pain between the 3 surgical approach groups, a 1 × 3 analysis of variance (ANOVA) was used to compare the Harris Hip scores 6 weeks after the THA procedures. In addition, a 2 × 3 (time × approach) ANOVA was used for analysis of the gait variables. *Time* was defined as the preoperative or 6-week postoperative time point, whereas *approach* was defined as the DL, P, or AL surgical approach for the THA procedure. A separate

**Fig. 1.** Example of marker placement.

ANOVA ($\alpha = .05$) was completed for each study variable of interest. Tukey post hoc testing was completed on any variables that were statistically different.

## Results

No significant differences existed between the surgical approach groups based on height, weight, or age (Table 1). No statistically significant interactions existed between time (preoperative and 6 weeks postoperative) and surgical approach (DL, P, and AL). No significant differences in Harris Hip Score existed between the approach groups 6 weeks after THA (Table 1).

No significant time or surgical approach differences existed for stance time, swing time, hip flexion at heel strike, peak hip flexion, peak hip ABD angle, or peak vertical GRF (Table 2). However, significant differences existed between the preoperative and 6-week postoperative time points independent of the surgical approach. Independent of surgical approach, subjects walked significantly faster ($P < .001$) 6 weeks (1.22 ± 0.21 m/s) after THA when compared with the preoperative time point (1.08 ± 0.20 m/s) (Table 2). Stride length ($P = .002$) and step length ($P = .034$) were significantly longer 6 weeks after THA independent of surgical approach (Table 2). In addition, subjects demonstrated an increase in peak hip extension ($P = .010$) during the stance phase 6 weeks after THA.

The only dependent variable that was influenced by surgical approach was the hip ADD/ABD angle at heel strike. The patients who had a THA using the P approach landed at heel strike in a more ABD position than the patients in either the DL or the AL approach groups ($P = .006$). Of note, this difference was present between groups at both the preoperative and postoperative time points (Fig. 2).

**Table 1.** Demographic Comparison Based on Surgical Approach

| | Direct Lateral | Posterior | Anterolateral |
|---|---|---|---|
| Age (y) | 58.0 ± 7.01 | 55.3 ± 8.16 | 55.4 ± 10.87 |
| Height (m) | 1.73 ± 0.12 | 1.75 ± 0.10 | 1.71 ± 0.10 |
| Weight (kg) | 82.98 ± 17.88 | 77.29 ± 16.93 | 87.64 ± 20.81 |
| Harris Hip Score (6 wk postoperative) | 77.75 ± 9.36 | 87.86 ± 6.52 | 84.92 ± 10.98 |

Values are presented as mean ± SD (no significant differences).

## Discussion

There are numerous surgical approaches that can be used to perform THA. There are proposed benefits and disadvantages to each of the approaches. The DL approach used in this study included a proximal split to the gluteus medius, which was limited to approximately 3 to 4 cm proximal to the greater trochanteric tip in an effort to avoid damage to the superior gluteal nerve. It is reported that abductor weakness can occur through denervation of the gluteus medius and minimus after damage to this nerve [2]. Weakness of the abductors could contribute to the increased incidence of limping that can be seen after this approach. Supporters of the P approach feel that the preservation of the abductor mechanism is responsible for the decreased

**Table 2.** Biomechanical Comparisons Between Surgical Approach and Preoperative to 6 weeks Postoperative

| | Direct Lateral | | Posterior | | Anterolateral | |
|---|---|---|---|---|---|---|
| | Preoperative | 6 wk | Preoperative | 6 wk | Preoperative | 6 wk |
| Stance time (% cycle) | 59.64 ± 2.77 | 58.03 ± 6.72 | 58.44 ± 2.76 | 60.08 ± 4.75 | 60.48 ± 5.24 | 60.29 ±3.31 |
| Swing time (% cycle) | 38.95 ± 3.71 | 38.28 ± 5.66 | 41.28 ± 2.67 | 39.66 ± 5.60 | 38.41 ± 5.27 | 39.74 ± 3.47 |
| Stride length (NORM) * | 0.69 ± 0.09 | 0.74 ± 0.11 | 0.72 ± 0.06 | 0.76 ± 0.054 | 0.69 ± 0.08 | 0.72 ± 0.077 |
| Step length (NORM) * | 0.34 ± 0.05 | 0.40 ± 0.09 | 0.37 ± 0.04 | 0.39 ± 0.09 | 0.34 ± 0.04 | 0.35 ± 0.04 |
| Walking speed (m/s) * | 1.03 ± 0.21 | 1.11 ± 0.26 | 1.14 ± 0.18 | 1.29 ± 0.17 | 1.06 ± 0.20 | 1.21 ± 0.20 |
| Hip flexion at HS (deg) | 32.18 ± 11.47 | 29.55 ± 7.57 | 31.20 ± 9.91 | 30.98 ± 8.23 | 32.41 ± 5.32 | 31.85 ± 7.81 |
| Peak hip flexion (deg) | 32.33 ± 11.41 | 29.82 ± 7.75 | 31.43 ± 9.95 | 31.03 ± 8.24 | 32.79 ± 8.45 | 31.95 ± 7.76 |
| Peak hip ABD (−) (deg) | −0.73 ± 3.56 | 0.85 ± 3.03 | −2.79 ± 4.58 | −2.45 ± 3.03 | −1.30 ± 3.76 | −0.14 ± 4.32 |
| Peak hip Ext (−) (deg) * | 6.49 ± 14.53 | 2.89 ± 8.57 | 6.98 ± 9.33 | 3.26 ± 8.33 | 7.90 ± 8.63 | 1.75 ± 8.19 |
| Peak vertical GRF (BW) | 1.01 ± 0.06 | 1.01 ± 0.06 | 1.02 ± 0.08 | 1.06 ± 0.14 | 0.99 ± 0.13 | 1.05 ± 0.14 |

Values are presented as mean ± SD.
NORM indicates normalized to subject's standing height; HS, variable of interest assessed at Heel Strike; Ext, extension; BW, normalized to the subject's body weight.
* $P < .05$ for preoperative to 6 weeks postoperative comparison.

incidence of limp seen with that exposure [24]. This protective effect appears to come at the expense of an increased risk of dislocation and potential sciatic nerve injury [25-27]. Advocates of the AL approach would inherently tout this exposure as having the ability to spare surgical violation of the abductors and at the same time avoid the risk of dislocation seen with the P approach. It follows that there could be some difference in functional recovery after the THA based on surgical approach. This proposed difference is difficult to measure and quantify, and therefore, the debate about which approaches are most idealized for rapid recovery has continued among orthopedic surgeons. Gait analysis studies such as the present study may provide a possible means of documenting and quantifying recovery.

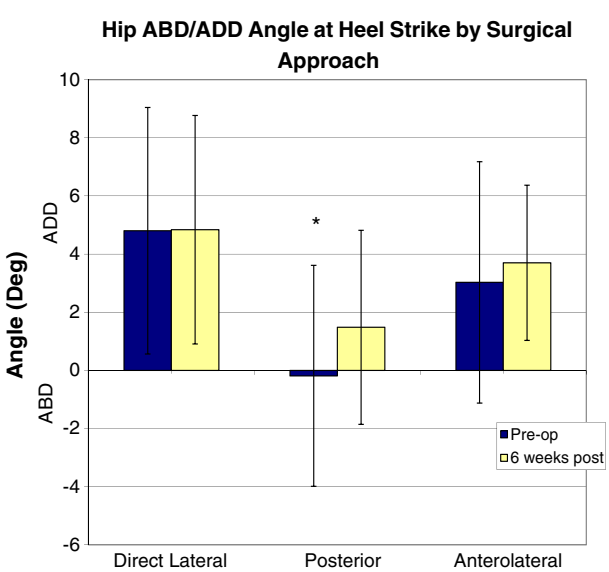


**Fig. 2.** Effect of surgical approach on hip ABD/ADD angle at heel strike. The P approach is significantly different from the DL and AL approaches. (asterisk indicates $P < .05$).

The use of gait analysis to compare approaches is not novel. Madsen et al [19] evaluated patients after THA done with either an AL or posterolateral approach. They noted that the P group had a higher percentage of patients who demonstrated normal gait. Whatling et al [11] reported similar findings of greater nonpathologic gait and a greater range of functional ability in their P approach group as opposed to their DL group. Both of these studies used normal control groups for comparison and did not include any preoperative gait analysis of the patients who underwent hip arthroplasty. Other studies from Lugade et al [12] and Meneghini et al [10] have included preoperative gait analysis when comparing abductor sparing approaches to the hip. Both investigators not only report results that seem to support some protective effect of sparing the abductor mechanism but also document improvement in gait regardless of surgical approach after THA, which is in agreement with the results of this study.

The present study examined gait mechanics after THA using three different surgical approaches (DL, P, and AL). As would be expected at 6 weeks after surgery, the patients walked faster, had a greater step length, and had a greater stride length. The only other significant finding was an increase in peak hip extension ($P = .010$) during the stance phase 6 weeks after THA. This limit in hip extension preoperatively may be explained by flexion contracture or capsular tightness associated with a lack of use in association with a limited range of motion. In all of the approaches, some extent and combinations of capsular releases are performed during the surgery. It is possible that the increased capsular laxity secondary to release in combination with the reduction in pain experienced by most may allow the patient to use the additional hip extension range of motion (ROM) postoperatively.

There was only one difference noted between the three approach groups. The patients in the P group landed at heel strike in a more abducted position than

the patients in either the DL or the AL approach groups. This was a main effect for surgical approach, indicating that the difference in ABD angle at heel strike was different between the surgical approaches independent of the time point that was being examined. This increased hip ABD simply appears to be a difference in how this particular study group walked, considering they exhibited a similar difference preoperatively. It is therefore not likely that this represents a protective effect of ABD afforded by the P approach.

Limitations of this study include a small sample size of only 35 patients who were divided into three surgical approach groups. A post hoc effect size assessment revealed that no effect size indices were greater than 0.50 in for any of the relevant comparisons. As a result, it would be expected that any difference attributed to a larger sample size alone would have minimal clinical relevance. In addition, the only pain or self-reported clinical outcome measure that is reported in this patient population was the Harris Hip Score. Although no additional outcome measures were reported in this study, the Harris Hip score results indicated no significant difference 6 weeks after THA between the three surgical approach groups. In addition, each of the surgical approach groups represents the patients of a single surgeon; therefore, surgical technique of a single surgeon could influence the result of an entire surgical approach group.

The results of this study indicate that little difference in gait mechanics exists after THA performed using the P, DL, and an AL approach 6 weeks after THA. The limited statistically significant differences that exists between the three approach groups suggests that restoration of gait is minimally affected by the approach itself. The lack of difference that exists should be considered as surgeons select their surgical approach of choice. It may be that other approach associated issues such as dislocation rate, periprosthetic fracture rate, and reproducibility of operative technique should be considered instead of restoration of normal gait mechanics when choosing a surgical approach to use. Gait analysis studies allow the investigators to look at a large amount of data and more physical activities than just level ground self-selected speed walking. The aim of future studies should address if surgical approaches play a role in altering joint mechanics during other activities of daily living such as stair climbing.

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