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Similar Improvement in Gait Parameters Following Direct Anterior & Posterior Approach Total Hip Arthroplasty

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ABSTRACT

We compared gait parameters prior to, at 6 months and 1 year following total hip arthroplasty (THA) performed via direct anterior approach (DAA) and posterior approach (PA) by a single surgeon in 22 patients. A gait analysis system involving reflective markers, infrared cameras and a multicomponent force plate was utilized. Postoperatively, the study cohort demonstrated improvement in flexion/extension range of motion (ROM) ($P = 0.001$), peak flexion ($P = 0.005$) and extension ($P = 0.002$) moments with no differences between groups. Internal/external ROM improved significantly in the DAA group ($P = 0.04$) with no change in the PA group. THA performed via DAA and PA offers similar improvement in gait parameters with the exception of internal/external ROM which might be related to the release and repair of external rotators during PA THA.

Gait analysis is an objective, established method for analyzing the effect of various surgical procedures for coxarthrosis including total hip arthroplasty (THA) [1]. Despite the improvement in clinical function and quality of life after THA, some studies have shown persistent gait anomalies in patients up to 10 years after THA [1–3]. It has also been used to quantify differences in postoperative recovery with minimally invasive and conventional THA as well as THA performed with different approaches [4–6]. This is based on the understanding that different approaches alter the function of different groups of muscles to a varying extent due to trauma incurred during the surgical approach.

The direct anterior approach (DAA) to THA uses the interval between the gluteal and tensor muscles laterally and the sartorius and rectus femoris muscles medially. There is an increased interest in this approach recently as 1) it is thought to be a muscle sparing procedure, 2) with lower dislocation rate which mitigates the need for postoperative hip precautions [7,8] and 3) the ability to confirm component positioning with fluoroscopy intra-operatively. Meneghini et al, in a cadaveric study, however, demonstrated similar overall muscle damage with the DAA and the conventional posterior approach (PA) [9]. There was less damage to the gluteus minimus with the DAA (a mean of 8% with DAA vs 18% via the PA); but, the tensor fascia lata muscle as well as the direct head of the rectus femoris incurred greater damage with the DAA (a mean of 31% and 12% respectively). The piriformis or conjoined tendon was transected in 50% of the anterior approach hips whereas all external rotators were intentionally detached and subsequently repaired in the PA.

Prospective longitudinal studies have shown significant improvements in a number of time–distance (spatiotemporal) and kinematic variables [10,11] as well as improvement in gait symmetry [12] after DAA THA as compared to anterolateral THA. However, a limited number of studies have compared the differences in the recovery of gait parameters after DAA and PA THA. Ward et al [4] and Mafflueti et al [13] couldn't demonstrate any significant differences in spatiotemporal gait parameters with these two approaches; however both of these were cross-sectional studies with no data on preoperative gait parameters. A recent study comparing computer navigated DAA THA and conventional PA THA reported similar recovery of spatiotemporal gait parameters and frontal plane angular movements of the pelvis and thorax [14].

The aim of our prospective, non-randomized study was to investigate and compare changes in 3-dimensional kinematics and kinetics of the hip joint in addition to the spatiotemporal gait parameters after THA performed via the DAA and PA. We hypothesized that there would be differences between groups corresponding to the damage subjected to the abductors and external rotators during PA THA and to the rectus femoris and tensor fascia lata during DAA THA.

Methods

All patients undergoing primary THA by a single fellowship trained arthroplasty surgeon at a single center who qualified according to pre-specified inclusion and exclusion criteria were invited to participate. The inclusion criteria were age of 45–70 years, cementless, unilateral

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THA and a diagnosis of primary osteoarthritis of the hip. Patients with a diagnosis other than primary degenerative hip arthrosis, history of previous orthopedic surgery on the ipsilateral lower extremity, patients with polyarthritis, neurological disorder known to affect gait, Crowe type 3 or 4 dysplasia, inability to walk without a cane or a walker and patients who were not willing to comply with the study protocol were excluded from participation in the study. Patients in the PA group consisted of patients who underwent PA THA by the senior surgeon from June 2008 through June 2009; whereas the DAA group consisted of patients operated by the same surgeon from April 2010 to June 2011. The PA was the only approach utilized for THA by the senior surgeon up to June 2009 with greater than 2000 PA THAs performed by him at the time of commencement of the study. DAA was utilized for all patients in the time period while recruiting patients of the DAA group except on 3 occasions; two involving a hip with presence of hardware which was removed at the time of THA and the third patient had a large gluteus medius tear which was repaired during the procedure. Patients in the DAA group were recruited after 100 DAA THAs were performed by the senior surgeon to minimize the influence of the learning curve. A written, informed consent was taken from all patients participating in the study and an IRB approval was obtained prior to commencement of the study.

22 patients participated in the study; 11 in PA group (6 males and 5 females) and 11 in the DAA group (6 males and 5 females). Within the DAA group, two patients did not complete the 6 month assessment in time but followed up for the 1 year assessment. Three other patients completed their 6 month assessments but didn't complete their 1 year assessments. Thus, 9 patients were available at 6 months and 8 patients at 1 year follow-up in the DAA group for analysis. Mean patient age in the PA group was 61.8 years (SD 9.1) and it was 58 years (SD 6.7) in the DAA group. Mean BMI values were 25.43 kg/m^2 (SD 3.08) in the PA group and 25.9 kg/m^2 (SD 2.23) in the DAA group. There were no significant differences between the groups in these demographic features.

Cementless acetabular components (Trident PSL, Stryker, Mahwah, New Jersey in PA THA; R3, Smith & Nephew, Memphis, Tennessee in DAA THA), a tapered wedge design of the femoral component (Accolade, Stryker, Mahwah, New Jersey in PA THA; Anthology, Smith & Nephew, Memphis, Tennessee in DAA THA) with a ceramic on polyethylene bearing were utilized for THA in both the groups. Head sizes were selected based on the cup size (a head size of 36 mm was used when the cup size was 54 mm or greater and 32 mm when the cup size was less than 54 mm). There was a similar distribution of 32 and 36 mm head sizes in the two groups (PA group, 32 mm–4 hips, 36 mm–7 hips; DAA group, 32 mm–4 hips, 36 mm–7 hips; $P = 0.67$). DAA cases were performed with a slight modification of the technique described by Lovell [15], with anterior capsulotomy and subsequent repair, the use of a standard operating table with a table mounted femoral elevator (Omni-Tract Surgical, St. Paul, Minnesota), selective soft tissue releases based on the mobility of the femur (conjoined tendon was released in most cases and piriformis was released in some), and the use of fluoroscopy in every case for assessing component positioning and limb-lengths. Stability was assessed with provocative testing in extension and external rotation, and leg length and socket position were adjusted to achieve stability. Leg length was determined by a direct comparison between the legs and using the C-arm. PA THAs were performed as previously reported [16], with a repair of the capsule and all muscular structures (piriformis, conjoined tendon, quadratus and gluteus maximus tendon) through trochanteric drill holes and/or direct repair. Stability was assessed with provocative testing in flexion and internal rotation. Leg length and socket position were adjusted to achieve stability. Leg length was determined using a Steinman pin in the infracotyloid groove as previously described [17].

All patients were managed with the same multi-modal anesthesia and analgesia protocol. Patients were first seen by a physical therapist on the morning after surgery and received 2 sessions of physical therapy daily until discharge from the hospital. Patients were encouraged to move from bed to chair on the first postoperative day with weight bearing as tolerated. No hip precautions were imposed on patients receiving the DAA, whereas patients who received THA through the PA were advised to use an abduction pillow, high chair and avoid a combination of flexion of more than 90° with adduction and internal rotation until 6 weeks postoperatively. Upon discharge, patients were advised to resume activities as they could tolerate, with hip comfort being their guide. Patients were also encouraged to progress to a cane as tolerated. Apart from the difference in hip precautions, standardized rehabilitation instructions were issued to physical therapists taking care of patients at home or at outpatient physical therapy facilities.

Gait testing for patients undergoing THA occurred before surgery, at 6 months and 1 year after surgery. Kinematic and ground reaction force data were recorded as subjects walked at self-selected pace across a six-meter walkway. Reflective markers were placed over the calcaneous, first and fifth metatarsals, medial and lateral malleoli, anterior shank, medial and lateral femoral condyles, anterior thigh, greater trochanter, sacrum and anterior superior iliac spine of the involved leg and the greater trochanter and anterior superior iliac spine of the contralateral leg. Marker positions were collected at 60 Hz using five infrared cameras (Qtrac, Qualisys, Gothenburg, Sweden). The motion data were then filtered with a fourth-order Butterworth low-pass filter with a cutoff frequency of 10 Hz in order to eliminate any high frequency noise. Ground reaction forces (GRF) were recorded at 960 Hz with a multi-component force plate (Kistler Instrument Corp., Anherst, NY, USA) incorporated into the walkway. Subjects preformed five gait trials and were instructed to walk as naturally as possible contacting the force plate with only the involved limb. Trials in which the foot did not land completely on the force plate or the subject altered his or her gait pattern to target the force plate were discarded and the trial was repeated.

Spatiotemporal parameters analyzed were gait velocity and single-leg stance time. Joint kinetic and kinematic variables were calculated during the stance phase. Sagittal (flexion/extension), frontal (adduction/abduction) and transverse [internal/external rotation; IR/ER] plane hip angles and moments were calculated using specialized computer software (Visual 3D, C-Motion, Inc., Rockville, MD, USA). Hip flexion, adduction and internal rotation angles and moments were defined as positive values and all moments were reported as internal moments.

Table 1
Mean Values & Standard Deviations for Hip Range of Motion (Degrees).

	DAA	PA	Group[a]	Group by Time[b]	Time[c]
Sagittal plane (Flexion/extension)					
Presurgery	30 (12)	28 (9)	0.53		
6 months	41 (9)	35 (8)	0.16	0.58	0.003[d]
1 year	46 (5)	36 (7)	0.01[d]	0.25	0.001[d]
Frontal plane (Abduction/adduction)					
Presurgery	9.6 (2.6)	6.9 (1.7)	0.02[d]		
6 months	9.6 (1)	10.8 (3.7)	0.32	0.007[d]	0.01[d]
1 year	10.6 (2.6)	12.6 (4.1)	0.26	0.02[d]	0.01[d]
Transverse (internal/external rotation)					
Presurgery	10.7 (4.3)	9.14 (4.5)	0.45		
6 months	15 (6.5)	9.07 (3.4)	0.03[d]	0.04[d]	0.05[d]
1 year	14 (6.5)	9.09 (2.5)	0.04[d]	0.04[d]	0.09

DAA, Direct anterior approach; PA, Posterolateral approach.
[a] Independent t-test between groups.
[b] Repeated measures ANOVA (group by time; preoperative to 6 months; preoperative to 1 year).
[c] Repeated measures ANOVA (time; preoperative to 6 months; preoperative to 1 year).
[d] Significant value.

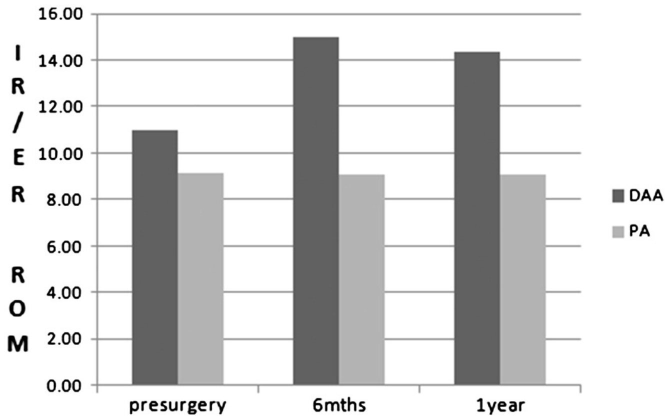

Fig. 1. Graph showing that transverse plane (internal/external) range of motion significantly improved in the DAA group and was higher than the PA group (no change).

Clinical function was documented using Harris Hip scores (HHS) corresponding to patient evaluation preoperatively, at 6 months and at 1 year. Two separate repeated-measures analysis of variance (ANOVA, Time by Surgical Approach) were used to compare range of motion and peak hip moments in all three planes, as well as gait velocity and Harris Hip Score (HHS), over time and between surgical groups. The first ANOVA compared the groups between the pre-op measurements and the 6-month follow-up and the second ANOVA compared them from pre-op to 1-year follow-up. When significant main effects or interactions were found, paired t-tests were used to compare variables measured at pre-op, 6 months and 1 year follow-up. In addition, independent t-tests were also used to assess group differences in gait parameters preoperatively, at 6 months and at 1 year. A repeated-measures ANOVA was also carried out to compare gait metrics in subjects with 32 mm and 36 mm heads from preoperative to 6 months and preoperative to 1 year. Bonferroni corrections were applied to planned post-hoc comparisons where applicable.

Results

Spatiotemporal Parameters

Preoperatively, the gait velocity was higher in the DAA group (1.21 ± 0.20 m/s) as compared to the PA group (0.91 ± 0.23 m/s; $P = 0.005$). It significantly improved ($P = 0.001$) at 6 months only in the PA group (1.10 ± 0.25 m/s) to become similar to that of the DAA group (1.26 ± 0.24 m/s, $P = 0.15$). The gait velocity was higher in the DAA group (1.36 ± 0.18 m/s) as compared to the PA group (1.25 ± 0.12 m/s) at the 1-year mark ($P = 0.04$). Correspondingly, the single-leg stance time was significantly lower in the DAA group preoperatively (DAA: 0.69 ± 0.06 s; PA: 0.83 ± 0.18 s; $P = 0.04$), became similar to the PA group at 6 months (DAA: 0.68 ± 0.17 s; PA: 0.77 ± 0.23 s; $P = 0.22$) and lower at 1 year (DAA: 0.63 ± 0.12 s; PA: 0.74 ± 0.21 s; $P = 0.03$)

Joint Kinematics (Table 1)

Flexion/extension Range of motion (ROM) significantly improved over time in the study cohort with no differences between groups. However, the ROM values were higher in the DAA group as compared to PA group at 1-year. The abduction/adduction ROM was significantly higher in the DAA group preoperatively. It improved significantly in the PA group and not in the DAA group, so that it was similar between groups at 6-month and 1-year follow-up. ER/IR ROM significantly improved in the DAA group but not in the PA group (Fig. 1). It was similar in both groups preoperatively but higher in the DAA group at both 6-month and 1-year follow-up.

Joint Kinetics (Table 2)

Peak flexion and extension torque moments improved significantly in the study cohort postoperatively with no significant differences between groups. There were no significant interactions seen with peak abduction and adduction moments. Peak IR moment improved significantly postoperatively at 1-year with no differences between groups. There was a trend for lower peak ER torque in the PA group as compared to the DAA group at 6-months and 1 year.

Clinical Scores

In the PA group, the mean HHS improved from 53.32 (SD 9.0) preoperatively to 87.47 (SD 9.0) at 6-month and 91.34 (SD 7.6) at 1-year follow-up. Mean Harris hip scores in DAA group improved from 54.84 (SD 10.5) to 82.03 (SD 15.7) at 6-month and 92.33 (SD 7.1) at 1-year follow up. There were no differences between groups in the improvement of HHS (6 months $P = 0.56$; 1 year $P = 0.42$).

Table 2
Mean Values & Standard Deviations of Peak Moments (N m/kg).

	Sagittal		Frontal		Transverse	
	EXT	FLEX	ABD	ADD	ER	IR
Presurgery						
DAA	0.74 (0.37)	1.14 (0.39)	0.99 (0.26)	0.25 (0.09)	0.29 (0.20)	0.12 (0.07)
PA	0.45 (0.19)	0.93 (0.37)	0.90 (0.24)	0.16 (0.08)	0.19 (0.11)	0.08 (0.04)
Group[a]	0.05	0.23	0.43	0.04[d]	0.21	0.11
6 months						
DAA	0.82 (0.27)	1.31 (0.26)	1.04 (0.22)	0.23 (0.11)	0.31(0.16)	0.13 (0.10)
PA	0.59 (0.11)	1.09 (0.21)	0.95 (0.19)	0.16 (0.07)	0.20 (0.10)	0.12 (0.08)
Group[a]	0.04[d]	0.05	0.30	0.13	0.09	0.85
group by time[b]	0.55	0.94	0.93	0.66	0.93	0.41
Time[c]	0.05	0.08	0.26	0.46	0.69	0.19
1 year						
DAA	1.04 (0.33)	1.60 (0.29)	1.05 (0.18)	0.28 (0.19)	0.31(0.12)	0.19 (0.06)
PA	0.70 (0.29)	1.31 (0.17)	1.10 (0.22)	0.20 (0.09)	0.16 (0.07)	0.19 (0.08)
Group[a]	0.09	0.09	0.61	0.41	0.05	0.92
group by time[b]	0.87	0.93	0.24	0.43	0.52	0.31
Time[c]	0.002[d]	0.005[d]	0.10	0.63	0.66	0.002[d]

DAA, Direct anterior approach; PA, Posterolateral approach; EXT, extension; FLEX, flexion; ABD, abduction; ADD, adduction; ER, external rotation; IR, internal rotation.
[a] Independent t-test between groups.
[b] Repeated measures ANOVA (group by time; preoperative to 6 mths; preoperative to 1 year).
[c] Repeated measures ANOVA (time; preoperative to 6 mths; preoperative to 1 year).
[d] Significant value.

No significant between-group interactions were seen in any of the gait parameters between subjects with 32 mm heads and 36 mm heads from preoperative to 6 months and preoperative to 1 year (all P values > 0.05).

Discussion

This study highlights that both PA THA and DAA THA have a similar pattern of recovery for most gait parameters. There was a statistically significant improvement in the gait velocity in the PA group. There was a significant difference between the two groups with the change in the hip ROM in the transverse plane (IR/ER), which improved in the DAA group but diminished in the PA group postoperatively.

Abduction/adduction ROM improved significantly in the PA group and was similar to that of the DAA group at 6-month and 1-year follow-up. Similarly, there were no group differences in the peak abductor moments during stance phase. This indicates that damage to the abductors (specifically gluteus minimus as noted in the cadaveric study) in the PA group did not translate into clinically measurable effects on gait parameters.

An important finding in this study, which has not been discussed before, is the clinical effect of the release of external rotators during PA THA. During a typical gait cycle, the hip is in internal rotation during the loading response, mid and terminal part of the stance phase and goes into ER during the pre-swing part of the stance phase [18]. This hip ROM in the transverse plane was similar in both the groups preoperatively. It improved significantly in the DAA group but diminished in the PA group after surgery. The deficit persisted up to 1 year postoperatively despite the meticulous repair of the external rotators and the posterior capsule [16]. Hakkinen et al in a prospective study observed that active external rotation decreased in patients who underwent PA hip resurfacing which persisted up to 1-year postoperatively [19,20]. They have also reported a decrease in ER strength in the same group postoperatively. It has been postulated that the decreased ER strength may contribute to abnormal lumbopelvic posture and contribute to abnormalities in the lumbar motion and lower extremities during walking and other daily activities [19,20]. A second factor associated with this finding could be the early period of motion limitation for dislocation precautions. None of the patients in our study underwent any specific exercises for IR/ER motion and strength. A specific rehabilitation program focused on improving IR/ER ROM and strength might have a role in improving this particular gait pattern after PA THA, although the clinical ramifications of this finding are not clear and may be negligible.

Peak flexion/extension torque improved (time effect) with no differences between groups. Thus, damage to the rectus femoris mucle during the DAA as demonstrated in the cadaveric study did not result in significant gait alterations in our study. Rectus femoris is active for a very short period during the initial swing phase of the gait cycle and its activity is proportional to the walking speed [21,22]. Hence, no stance phase gait alterations were detected especially when subjects were instructed to walk at self-selected normal pace.

Limitations of the study include the lack of a healthy control group making it difficult to determine if the gait parameters in the operative groups were restored to normal levels. However, the aim of the study was to specifically compare differences in recovery of gait patterns after DAA and PA THA. This was a non-randomized study design. The subjects for the two groups were enrolled in two different time periods. The surgeon was consistently using the same approach for most of his patients when the study subjects were enrolled (posterior while recruiting PA group patients and direct anterior while recruiting DAA group patients). This eliminates any selection bias arising from offering a particular approach to specific patients. There were differences noted in some of the preoperative gait parameters including walking velocities between the two groups. There was a significant improvement in the walking velocity in the PA group, but it was still lower than the DAA group at 1-year due to lower preoperative values. However, previous studies have shown that there are no differences in the spatiotemporal gait parameters between patients undergoing DAA and PA THA postoperatively [4,13]. This is a preliminary study and probably the sample size may be inadequate to detect significant interactions among other parameters. Also, no assessment was done early in the postoperative course (at 6 weeks or 3 months) which might have revealed significant differences between the two groups as shown in other studies comparing DAA with the anterolateral approach [10–12].

In conclusion, there was a similar pattern of recovery of gait parameters with patients undergoing DAA THA and PA THA at 6-months and 1-year postoperatively. Both approaches to THA provided similar improvement of postoperative function. The only important difference was the decrease in the ER/IR ROM with the PA. Further studies may be required to assess if these small alterations in gait parameters are of any functional relevance especially in young patients with higher activity levels. Also, the role of specific rehabilitation directed to ER/IR motion in improving this particular gait parameter can be a consideration for future studies.

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