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ORIGINAL PAPER

No differences between direct anterior and lateral approach for primary total hip arthroplasty related to muscle damage or functional outcome

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Abstract

Purpose The aim was to compare the muscle damage and functional outcomes between patients who underwent total hip arthroplasty through a direct anterior (49 patients) or a lateral approach (50 patients).

Methods A randomized, controlled, prospective study. The study variables were muscle damage based on post-operative levels of serum markers (citokynes and acute phase reactants) and MRI, and Harris hip score.

Results Post-operatively, there were significantly higher mean levels in the lateral group related to interleukin 6 and 8, and tumor necrosis factor-alpha up to fourth postoperative day. By MRI at six post-operative months, the fatty atrophy in the gluteus muscles was more in the lateral group, but similar in the other muscles. The mean thickness of the tensor fasciae latae was significantly lower in the anterior group. Functional outcome was similar between groups at three and 12 post-operative months.

Conclusions Muscle damage due to the surgical approach had no influence on functional outcome after three post-operative months. Both anterior and lateral approaches for THA are similarly safe and feasible, so the choice depends only on the preference and experience of the surgeon.

Keywords Hip approach · Functional outcome · Muscle damage · Total hip arthroplasty

Introduction

Surgical approach for primary total hip arthroplasty (THA) is still a controversial topic. There are several surgical approaches that can be used to perform THA. The most commonly used are the posterior, anterolateral, direct anterior, and lateral approaches, each with advantages and disadvantages. Worldwide, the posterior approach remains the most used, but the direct anterior and lateral approaches are increasing in popularity [1], possibly due to the reported lower dislocation rates [2, 3]. It is difficult to measure and quantify the differences, and the debate about which approach is most successful for rapid recovery has continued among orthopedic surgeons [4]. In addition, the literature also suggests that minimizing muscle damage during surgery is a reason for patients to choose particular surgeons who practice muscle-sparing techniques [5].

In theory, the direct anterior approach should cause less tissue damage than the direct lateral approach, as it is performed through a plane between neurlogical tissue and intermuscular plane without muscle transection [6]. On the other hand, some authors suggest that the detachment of the gluteus medius tendon may be a damaging factor in the direct lateral approach [7]. However, there are few clinical studies in the literature comparing anterior and lateral approach. Two of these were retrospective and reported outcomes at the early post-operative [4, 8], and one was prospective with short-term follow-up [9]. Other studies have analyzed only specific clinical aspects, such as gait in the early post-operative [10]. Only one study compared muscle damage by MRI [11].

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To our knowledge, there are no studies in the literature in which both functional outcomes and muscle damage have been analyzed in prospective cohorts comparing direct lateral and anterior approaches. On the basis that there is strong evidence that muscular regenerative process take place within the first weeks after injury [12], our hypothesis was that the muscle damage caused by one or another surgical approach did not influence functional outcomes.

Thus, our objective was to compare muscle damage by mean of both MRI and inflammatory marker levels between patients who underwent primary THA through a direct lateral or anterior approach, and if this had clinical relevance.

Materials and methods

A randomized, controlled, prospective study was designed to compare the outcomes between direct lateral and anterior approach in patients undergoing elective primary THA. The study was approved by our local Ethical Committee and informed consent was required.

Patient selection

The inclusion criteria were aged 55 or older, diagnosis of primary osteoarthritis, and asymptomatic opposite hip. The exclusion criteria included prior hip surgery, arthroplasty to treat a fracture, inflammatory arthropathies, autoimmune disease, immunosuppressive treatment, or cancer. Randomization to lateral or anterior group was based on a list of random numbers.

Operative protocol

All operations were performed under spinal anesthesia by the same team of surgeons. In both groups, the skin incision was minimized to approximately 10 cm. The Medacta hip system (Quadra stem, Versafit cup, Medacta international, Castel San Pietro, Switzerland) was used in both groups. In all cases, the acetabular component was cementless in titanium alloy. A titanium-niobium cementless stem was used in patients under 70 years, and stainless steel cemented stem in those older than 70 years (eight patients in anterior group, and six in lateral group). All patients received a standard 28 mm-diameter metallic head.

In the lateral group, a direct lateral approach as described by Hardinge [13] was used. Briefly, the gluteus medius and minimus were incised and detached ventrally from the greater trochanter. The incision was not extended more than 3 cm above greater trochanter to prevent injury to superior gluteal nerve. After implantation, the tendons were reattached with transperiosteal sutures. In the anterior group, a direct anterior approach as described by Matta et al. [6] was used. Arthrotomy was performed by retracting the muscles rectus femoris and iliopsoas medially and gluteus medius laterally. According to standard protocol, all patients had antibiotic prophylaxis with cefazoline for 24 hours (started 30 minutes prior to the skin incision), and thromboembolic prophylaxis with low-molecular-weight heparin for 30 days. All patients were allowed to stand on the second post-operative day, and were instructed to weight-bearing as tolerated with the use of a walker.

Evaluations

Muscle damage was the primary outcome indicator which was assessed by means of serum levels of markers of inflammation, acute phase reactants, and MRI. Among markers, interleukin (IL)-1, IL-6, IL-8, IL-10, IL-12, and tumor necrosis factor-alpha (TNF) were recorded as global measures of inflammation and surgical insult. These cytokines were measured on routine venous blood samples which were taken at immediate pre-operative, and post-operatively six hours, one, two and four days after surgery. Among acute phase reactants, creatine kinase (CK), erythrocyte sedimentation rate (ESR), and C-reactive protein (CRP) were measured on postoperative days two, four, 15, and 30.

MRI was made pre-operatively and at six post-operative months in all patients according to a standard protocol including axial, sagittal, and coronal views [14]. All MRI were independently analyzed by two experienced radiologists. The fatty atrophy was assessed for diverse muscles, such as tensor fasciae latae (TFL), gluteus maximus, medius and minimus, rectus femoris, sartorius, and iliopsoas. According to Müller et al. [15], fatty atrophy was divided into two grades. Grade-1 was defined when there was no fat or mild atrophy, and grade-2 when there was moderate or severe fatty atrophy. Muscle thickness was also recorded. The TFL and gluteus maximus were assessed at the level of greater trochanter, and gluteus medius and minimus at level of the acetabulum.

Functional evaluation was performed preoperatively and postoperatively at three, six and 12 months, by means of the Harris hip score [16]. The age at the time of surgery, body-mass index (BMI), incision length, and operative time were recorded. The overall drop in the hemoglobin was calculated as the difference between the level on post-operative 24 hours and the pre-operative. All clinical data were collected by independent observers who had not participated in the surgery.

Statistical analysis

A priori power analysis was performed to estimate the required number of patients for each study group which was based on the post-operative IL-6 level (primary variable) of a study published in the literature [17]. They reported a mean of 30.1 and standard deviation of 8.9. We assumed a power of

80 % and an alpha error of 0.05. With these figures, 46 patients were needed to detect a relevant clinical difference of 20 % between groups. Assuming a drop-out rate of 5 %, at least 48 patients in each group were required.

Statistical analyses were conducted with IBM-SPSS 19.0 software (IBM-SPSS, Armonk, NY, USA). Normal distribution was determined by the Kolmogorov-Smirnov test. For comparison between groups, we used the unpaired Student *t*-test or non-parametric Mann–Whitney *U*-test for continuous variables, and the chi-square test, Fisher exact test or Mantel-Haenszel test for categorical variables. For comparison between pre- and post-operative data, the paired Student *t*-test or Wilcoxon signed-rank test were used. Correlation was made by Pearson coefficient. Statistical significance was set at p less than 0.05.

Results

One hundred and two consecutive patients who met inclusion criteria were invited to participate and none refused. Later, we excluded from analysis one patient due to intra-operative trochanteric fracture (lateral group), and two others due to early wound infection (anterior group), leaving 99 valid patients (50 in lateral group, and 49 in anterior group). There was no loss to follow-up or discontinued study protocol. Pre-operative and peri-operative data are shown in Table 1. There were no significant differences between groups, except for mean incision length ($p = 0.001$). In both groups, the mean hemoglobin level decreased significantly from pre-operative to post-operative ($p = 0.001$), with a significant difference between groups ($p = 0.018$).

Post-operatively, the mean levels of IL-6 and IL-8 significantly increased in both groups ($p = 0.001$), and there were no significant changes in the remaining cytokines or TNF (Table 2). Comparing both groups, at one post-operative day there were only significant differences in mean levels of IL-6 ($p = 0.001$) and IL-8 ($p = 0.003$), and at four days in mean levels of IL-8 ($p = 0.021$) and TFN ($p = 0.014$), these values being significantly less in those patients operated by anterior approach.

In regards to the acute phase reactants (Table 3), mean levels of CK and CRP were significantly increased until the fourth post-operative day ($p = 0.001$) and then returned to baseline in both groups. Comparing the groups, post-operative mean level of CK was significantly higher in lateral group than in anterior group up to day 4 ($p = 0.001$), and CRP up to day 15 ($p = 0.001$). The mean level of ESR was significantly increased up to day 30 in both groups.

In regards to the MRI outcomes (Table 4), there were no significant differences in pre-operative muscle status between groups, but thickness of fasciae latae muscle. Post-operatively, there was a significant higher grade of fatty atrophy in the gluteus muscles when the lateral approach was used compared to the anterior approach ($p = 0.004$). In the lateral group, 18 patients (36.7 %) had fatty atrophy in the gluteus maximus, 25 (51.0 %) in the gluteus medius, and 36 (73.4 %) in the gluteus

Table 1 Pre- and peri-operative data

	Lateral group	Anterior group	p value
Age (yr)	63.5 (12.5)	64.8 (10.1)	0.555
Gender (male/female)	26/23	26/24	0.689
BMI (kg/m2)	26.9 (3.1)	26.6 (3.9)	0.638
Harris score	42.9 (15.2)	44.4 (13.6)	0.606
Creatine kinase (U/L)	76.9 (37.6)	75.1 (30.2)	0.789
C-reactive protein (mg/L)	0.4 (0.6)	0.4 (0.5)	0.924
ESR (mm/h)	11.3 (10.4)	11.4 (10.9)	0.966
Interleukin-1 (pg/mL)	3.1 (0.2)	3.1 (0.1)	0.840
Interleukin-6 (pg/mL)	3.7 (1.0)	3.9 (0.6)	0.485
Interleukin-8 (pg/mL)	24.8 (9.2)	23.7 (5.0)	0.679
Interleukin-10 (pg/mL)	1.7 (0.3)	1.6 (0.4)	0.655
Interleukin-12 (pg/mL)	1.4 (0.8)	1.1 (0.2)	0.309
TNF (pg/mL)	1.3 (0.2)	1.4 (0.6)	0.764
Surgery time (min)	82.2 (15.2)	78.2 (16.2)	0.209
Incision length (cm)	11.5 (0.7)	10.4 (0.9)	0.001

Continuous data are presented as mean (standard deviation). *BMI* Body mass index, *Hb* Hemoglobin, *ESR* Erythrocyte sedimentation rate, *IL* Interleukin, *TNF* Tumor necrosis factor-alpha

Table 2 Cytokine levels at different post-operative times

	Lateral group	Anterior group	p value
IL-1 6 h	3.1 (1.6)	3.1 (1.5)	0.256
IL-1 1 d	3.2 (0.1)	3.1 (0.2)	0.541
IL-1 4 d	3.0 (0.2)	3.1 (0.1)	0.434
IL-6 6 h	86.8 (32.8)	47.3 (14.3)	0.060
IL-6 1 d	72.5 (42.0)	50.3 (17.1)	0,001
IL-6 4 d	12.6 (6.3)	10.4 (4.3)	0.251
IL-8 6 h	46.3 (16.9)	31.9 (6.0)	0.003
IL-8 1 d	48.7 (19.4)	36.6 (8.1)	0.028
IL-8 4 d	33.9 (9.9)	27.1 (5.4)	0.021
IL-10 6 h	2.7 (1.3)	2.3 (0.9)	0.265
IL-10 1 d	2.2 (0.6)	2.0 (0.5)	0,249
IL-10 4 d	1.9 (0.4)	1.8 (0.2)	0.443
IL-12 6 h	1.2 (0.5)	1.1 (0.2)	0.249
IL-12 1 d	1.2 (0.3)	1.0 (0.1)	0.226
IL-12 4 d	1.2 (0.5)	1.1 (0.2)	0.236
TNF 6 h	1.2 (0.2)	1.3 (0.2)	0.170
TNF 1 d	1.4 (0.6)	1.3 (0.3)	0.493
TNF 4 d	1.4 (0.3)	1.2 (0.3)	0.014

Data are presented as mean (standard deviation). *IL* Interleukin [pg/mL], *TNF* Tumor necrosis factor-alpha [pg/mL]. Post-operative time (h: hours, d: days)

Table 3 Acute phase reactants at different post-operative times

	Lateral group	Anterior group	p value
CK 2 d	387.0 (174)	203.2 (53.7)	0.001
CK 4 d	189.8 (71.3)	105.0 (54.1)	0.001
CK 15 d	77.0 (18.1)	72.7 (20.2)	0.160
CK 30 d	74.3 (12.2)	73.1 (13.4)	0.644
CRP 2 d	14.4 (9.1)	11.4 (5.2)	0.046
CRP 4 d	10.1 (5.2)	7.1 (3.5)	0.001
CRP 15 d	1.0 (0.3)	0.7 (0.4)	0.001
CRP 30 d	0.3 (0.3)	0.4 (0.3)	0.991
ESR 2 d	26.0 (3.4)	24.5 (3.8)	0.695
ESR 4 d	46.2 (9.1)	44.8 (10.2)	0.473
ESR 15 d	26.1 (12.3)	20.5 (8.4)	0.009
ESR 30 d	16.7 (9.5)	10.2 (5.4)	0.001

Data are presented as mean (standard deviation). *CK* Creatine kinase [U/L], *CRP* C-reactive protein [mg/L], *ESR* Erythrocyte sedimentation rate [mm/h]. Post-operative time (d: days)

minimus, versus 6 (12.0 %), 5 (10.0 %), and 14 (28.0 %), respectively, in the anterior group ($p = 0.003$, 0.001, 0.001, respectively). The gluteus minimus tendon was affected in 16 patients (32.7 %) of the lateral group, and in none of the anterior group ($p = 0.001$). Fibrosis, hematoma or bursitis were identified in 22 patients (44.9 %) of the lateral group, and in two (4.0 %) of the anterior group ($p = 0.001$). The mean thickness of the TFL was significantly lower in the anterior group than in lateral group (17.5 mm versus 22.0 mm, $p = 0.001$). The mean thickness in the other muscles was similar between groups.

Table 4 Muscle fatty atrophy and thickness by MRI

	Lateral group	Anterior group	p value
Fatty atrophy grade-2[a]			
TFL: Pre	6 (12.2 %)	9 (18.0 %)	0.425
Pos	21 (42.9 %)	28 (56.0 %)	0.134
Gluteus max: Pre	2 (4.1 %)	1 (2.0 %)	0.617
Pos	18 (36.7 %)	6 (12.0 %)	0.004
Gluteus med: Pre	2 (4.1 %)	0	0.242
Pos	25 (51.0 %)	5 (10.0 %)	0.001
Gluteus min: Pre	6 (12.2 %)	3 (6.0 %)	0.318
Pos	36 (75.0 %)	14 (28.0 %)	0.001
Rectus femoris: Pre	0	2 (4.0 %)	0.495
Pos	2 (4.1 %)	4 /8.0 %)	0.348
Sartorius: Pre	1 (2.0 %)	0	0.499
Pos	2 (4.1 %)	3 (6.0 %)	0.509
Iliopsoas: Pre	0	0	–
Pos	1 (2.0 %)	3 (6.0 %)	0.617
Thickness[b]			
TFL: Pre	24.4 (4.5)	20.8 (4.4)	0.001
Pos	22.0 (4.3)	17.5 (3.9)	0.001
Gluteus max: Pre	32.3 (6.6)	32.2 (5.7)	0.935
Pos	28.5 (7.2)	29.5 (5.6)	0,441
Gluteus med/min: Pre	56.8 (7.6)	56.3 (9.8)	0.777
Pos	48.9 (10.8)	52.4 (10.3)	0.102

[a] Fatty atrophy grade-2 according to Müller et al. [13]: n (%). [b] Thickness [mm]: mean (standard deviation). *Pre* Preoperative, *Pos* Postoperative, *TFL* Tensor fasciae latae. Gluteus max (maximus), med (medius), and min (minimus)

Clinically, the mean Harris score significantly increased from pre to post-operative in both groups ($p = 0.001$). At three post-operative months, the mean score was 94.6 (sd, 10.2) in anterior group and 92.8 (sd, 11.3) in lateral group ($p = 0.407$), and at one post-operative year were 96.2 (sd, 10.1) and 94.5 (sd, 9.7), respectively ($p = 0.397$).

In both groups, there were no significant correlations between Harris score at final follow-up and the post-operative levels of cytokines at four post-operative days ($r = 0.12$; $p = 0.601$), or acute phase reactants at 30 post-operative days ($r = 0.20$; $p = 0.376$). Likewise, there was no significant relationship between categorized Harris score and fatty atrophy ($p = 0.686$).

Discussion

Direct lateral and anterior are two frequently used approaches for THA. The direct lateral approach proposed by Hardinge [13] was performed through the fasciae latae with splits of the gluteus medius and minimus and the vastus lateralis. Conceptually, the direct anterior approach is a tissue-sparing alternative, no detaching of muscles or tendons because the approach is undertaken via a natural interval among muscles (the fasciae latae muscle and the rectus femoris muscle) to enter the hip capsule [6]. Thus, this approach has a lower theoretical risk of causing muscle damage than the direct lateral approach.

Both MRI [15] and determination of serum interleukines [18] are two validated methods to quantify muscle damage after THA surgery. IL-6 is the most widely studied cytokine, which is formed as a response to tissue damage. The subsequent inflammatory action induced by IL-6 produces CRP and serum amyloid [17]. Like in another [18], in this study there was a significantly higher level of IL-6 in the lateral group at one post-operative day, but the difference between groups was not significant at four post-operative days. Several studies have demonstrated that the changes of interleukin levels are transient and return to baseline levels within a period of about three weeks after muscle injury [12, 15]. However, a study found a remarkable variability between individuals in the IL-6 response after THA surgery [18].

In our study there was a clear increase in CK levels between the post-operative days two and four, which was significantly higher in the lateral group than in the anterior group. CRP level reached their peak on postoperative day two in both groups, after which it decreased rapidly and returned to normal at 15 days. In this time interval, the mean increase in the lateral group was significantly higher than that in the anterior group. Post-operative increasing of CRP was consistent with other studies [19]. By contrast, another study [20] comparing three surgical approaches (anterior, lateral, and posterior) reported that the level of CK was not influenced by the type of approach.

MRI has been successfully used to analyze the muscle damage associated with surgical trauma after THA [15]. After removing the artifacts due to the implanted metallic material, the muscle changes and fatty atrophy reflect the muscle damage and correlate with muscle function [14]. In our study, fatty atrophy in gluteus muscles was found in many patients of the lateral group. Other studies found similar results of MRI [11], and observed fatty atrophy in the gluteus minimus muscle in 50 % of patients with lateral approach [15].

Comparing anterior and lateral approaches study [11] obtained an MRI one year post-operatively. They also found a higher rate of gluteus medius tendinosis and fatty atrophy of the abductor muscles in the lateral group, but unfortunately the clinical results were not reported. Another comparative study [8] reported a significant lower pain in the anterior group during the first 24 post-operative hours which was attributed to the muscle-sparing properties of the anterior approach.

However, a recent study [10] focused on gait analysis six weeks after THA in patients with different surgical approaches (direct lateral, posterior, and anterolateral). All patients showed increase in stride length, step length, peak hip extension, and walking speed regardless of surgical approach. The differences were not significant, and they concluded that the surgical approach did not appear to influence the early post-operative gait mechanics. In another study [15] of patients who received a THA via direct lateral approach, an MRI was made at three and 12 postoperative months. Partial gluteus atrophy and compensatory hypertrophy of the TFL was often observed but this did not appear to influence the functional outcomes. On the contrary, a prospective study [9] comparing anterior and lateral approaches reported significantly better functional outcomes at six weeks post-operatively in the patients with anterior approach, but these differences in clinical outcomes were abated when revisited at two years post-operatively. Reichert et al. [21] found comparable mid-term outcomes regarding functionality, pain, quality of life, and daily activity between direct anterior approach and direct transgluteal lateral approach. However, an adequate learning curve is necessary for the direct lateral approach to avoid malpositioning of components [22].

According to our findings, the lateral approach resulted in significantly greater muscle damage than in the anterior approach at the early post-operative period, but not at three post-operative months. Although some authors consider that reducing muscle damage can be important for choice of surgical access and improving outcomes [2, 6, 7], in view of our results we think that early muscle damage is clinically irrelevant.

A limitation of the study was the short follow-up. The study size was relatively small but had a statistical power of at least 80 %. The strengths of the study were the prospective controlled design, the use of only one system of THA, performed by only one surgeon team, homogeneous sample of patients, and no loss of follow-up.

In conclusion, muscle damage in the early post-operative period due to the surgical approach had no influence on functional outcome after three post-operative months. Both direct anterior and direct lateral approaches for THA are similarly safe and feasible, so the choice depends only on the preference and experience of the surgeon.

Compliance with ethical standards

Conflict of interest The authors declare have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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