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ORIGINAL PAPER

Prospective and comparative study of the anterolateral mini-invasive approach versus minimally invasive posterior approach for primary total hip replacement. Early results

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Abstract The interest in minimally invasive approaches for total hip replacement (THR) has not waned in any way. We carried out a prospective and comparative study in order to analyse the interest of the anterolateral minimal invasive (ALMI) approach in comparison with a minimally invasive posterior (MIP) approach. A group of 35 primary THRs with a large head using the ALMI approach was compared with a group of 43 THR performed through a MIP approach. The groups were not significantly different with respect to age, sex, bony mass index, ASA score, Charnley class, diagnoses and preoperative Womac index and PMA score. The preoperative Harris Hip Score was significantly lower in the ALMI group. The duration of surgical procedure was longer and the calculated blood loss more substantial in the ALMI group. The perioperative complications were significantly more frequent in this group, with four greater trochanter fractures, three false routes, one calcar fracture, and two rocking metal backs versus one femoral fracture in MIP group. Other postoperative data (implant positioning, morphine consumption, length of hospital stay, type of discharge) are comparable, as were the early functional results. No other complication has been noted during the first 6 months. The ALMI approach uses the intermuscular interval between the tensor fascia lata and the gluteus medius. It leaves intact the abductor muscles, the posterior capsule and the short external rotators. The early clinical results are excellent, despite the complications related to the initial learning curve for this approach and the use of a large head. The stability and the absence of muscular damage should permit acceleration of the postoperative rehabilitation in parallel with less perioperative complications after the initial learning curve.

Résumé Nous rapportons une étude prospective et comparative de l'abord antéro-latéral mini invasif de la hanche (AMLI) pour 35 arthroplasties totales primaires avec tête de grand diamètre avec l'abord mini invasif postérieur (MIP) pour 43 arthroplasties. Les deux groupes n'étaient pas différents selon l'âge, le sexe, l'indice de masse corporelle, le score ASA, la classe de Charnley, le diagnostic, l'index WOMAC et le score de Merle d'Aubigné et Postel. Le score de Harris était plus faible dans le groupe AMLI. La durée opératoire et la perte sanguine calculée étaient plus importantes dans le groupe AMLI. Dans ce même groupe les complications per-opératoires étaient plus fréquentes, avec quatre fractures du grand trochanter, trois fausses routes, une fracture du calcar, et deux bascules du composant acétabulaire alors qu'il n'y avait qu'une fracture fémorale dans le groupe MIP. Les autres données post-opératoires étaient identiques notamment le résultat fonctionnel précoce. Il n'y avait pas d'autre complication pendant les 6 premiers mois. L'abord antéro-latéral utilise l'intervalle entre le tenseur et le glutéus médius laissant intact les abducteurs, la capsule postérieure et les pelvi-trochantériens. Les résultats cliniques précoces étaient excellents en dépit des complications initiales liées à la courbe d'apprentissage et l'utilisation d'une tête de grand diamètre. La stabilité et l'absence de dommage musculaire permettaient une récupération post-opératoire plus précoce.

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Introduction

The jury is still out as to the advantages of using minimally invasive techniques for total hip replacement (THR). Several have been developed: the posterior mini-invasive

approach [12], the anterior mini-invasive approach [14, 23], the anterolateral mini-invasive approach [3, 5, 13] and the two-incision approach [4]. The oldest studies [4, 7, 10, 25] were very enthusiastic about this minimally invasive surgery and the first results shown were very encouraging. However, these early studies were often concerned with selected patients [24]: no major comorbidity, no overweight patients [7, 12] and no major architectural malformation. Other series have not confirmed these findings for the posterior mini-invasive approach [19, 24] or the direct lateral mini-invasive approach [9] in comparison with their respective standard-incision versions. For some authors [9, 24], the minimally invasive approaches are not particularly advantageous, apart from a smaller scar, and they are technically challenging, which can prejudice functional outcome in the long term. Several publications have even reported serious complications [2, 11]. For the authors, the concept of minimally invasive surgery implies maximum respect of all periarticular structures. To date, only the direct anterior approach [14, 23] and the anterolateral mini-invasive approach described by Bertin and Röttinger [5] are in line with this concept. The posterior mini-invasive approach requires sectioning the short external rotators [8, 12]. To carry out the direct lateral mini-invasive approach [3], the anterior third of the gluteus medius tendon must be elevated from the greater trochanter. As to the minimally invasive two-incision approach, Mardones et al. [16] showed the existence of lesions of the gluteus medius and/or the short external rotators.

No study reported in the literature has compared the results of minimally invasive approaches with each other and no study has analysed the results of the anterolateral mini-invasive (ALMI) approach, the so-called modified Watson-Jones approach. This anatomical approach uses the intermuscular interval between the tensor fascia lata and the gluteus medius. It offers excellent results because it leaves abductor function (gluteus medius and minimus) intact, as well as all the stabilising posterior tendon and capsule elements [20]. Because of this, it should offer excellent clinical results permitting less rehabilitation and more rapid recovery of function.

We performed a prospective study comparing the early results of THRs implanted through this ALMI approach [5] with those implanted through the posterior mini-invasive approach [8].

Materials and methods

Materials

In all cases, it was a primary THR. There was no selection with respect to weight, size, or body mass index (BMI). Our only criteria for exclusion were major architectural malformations (type Crowe II and beyond), and cases where removal of surgical material was required (fracture of neck of femur, fracture of acetabulum, femoral osteotomy, etc.).

We considered two distinct groups of patients: continuous and consecutive. All of them were operated on by the same senior surgeon (P.C.). The group which underwent surgery using the anterolateral mini-invasive approach consisted of 35 patients (21 men and 14 women). They were operated on using the technique described by Bertin and Röttinger [5]. They all received a hydroxylapatite-coated (HA) cementless Omnicase (Zimmer, Centerpulse) femoral stem, associated with a large Metasul head, with the exception of one case where the stem was of the same type but cemented. Durom (Zimmer, Centerpulse) cementless type acetabular cups were implanted in all patients. The group which underwent surgery using the posterior mini-invasive approach [8] consisted of 43 patients (28 men and 15 women). They were all operated on using the same technique and all received a Shuster (Zimmer, Centerpulse)-type acetabulum cup, and a hydroxylapatite-coated (HA) cementless Omnicase (Zimmer, Centerpulse)-type femoral component, curved in the sagittal plane. All the patients of the study underwent the same postoperative rehabilitation protocol: no orthesis and the patient put on his/her feet at day 1 (D_1) or D_2 with total weight bearing.

In both groups the diagnoses which established the indication for surgery were in the majority, arthrosis or osteonecrosis. Preoperatively, the two groups were not significantly different with respect to sex, age, BMI, ASA score, diagnosis, Charnley class, and preoperative functional scores (Postel and Merle d'Aubigné score and WOMAC osteoarthritis index). Only the modified Harris Hip Score [15] was significantly less favourable preoperatively in the anterolateral mini-invasive approach group. All preoperative clinical data are summarized in Table 1.

Method

The duration of surgical procedure was noted as well as eventual perioperative complications.

We studied the biological parameters of our patients: pre- and postoperative haemoglobin concentrations (in gr/dl) on D_1 and D_5, pre- and postoperative haematocrit rates on D_1 and D_5, number of packed red blood cells transfused in the postoperative period. Total blood loss was calculated using a standardised method of calculation [6].

During the immediate postoperative period, pain was evaluated using the volume of morphine-based analgesics taken in the first 5 days after the surgery. Length of hospital stay and type of discharge (to the home or to a rehabilitation unit) were noted.

Table 1 Preoperative clinical data. The values are given as the mean and the standard deviation, with minimum and maximum (*ALMI group* antero-lateral minimally invasive group, *MIP group* minimally invasive posterior group, *M* male, *F* female, *ASA* American Society of Anaesthesiology, *PMA* Postel et Merle d'Aubigné, *max* maximum, *OA* osteoarthrosis, *AVN* avascular necrosis, *RDHOA* rapidly destructive hip osteoarthritis, *RP* rheumatoid polyarthritis)

	ALMI group	MIP group	*P*
Number of hips	35	43	
Gender (M/F)	21/14	28/15	0.65
Age (years)	57±13 (32–83)	55,7±13.7 (23–77)	0.69
BMI (kg/m^2)	25.9±3.6 (18.9–34.9)	25.2±3.1 (20.7–32.5)	0.38
ASA score:			
– class: 1/2/3	18/14/3	28/11/4	0.40
– mean score	1.57	1.44	
Charnley class: A/B/C	12/15/8	20/21/2	0.06
Functional scores:			
– PMA score (max=18)	11.3±2.4 (6–15)	12±2.9 (5–16)	0.29
– Modified Harris Hip Score (max=100)	42.4±11.3 (16–59)	49.7±16.8 (15–89)	0.04
– WOMAC osteoarthritis index (max=100)	59.6±16.3 (26–77)	61±21.2 (18.7–97)	0.75
Diagnosis :	Primary OA : 15 Secondary OA : 5 AVN: 12 RDHOA: 2 RP: 1	Primary OA : 22 Secondary OA : 5 AVN: 14 RDHOA: 2	

Early clinical assessment was carried out in the form of questionnaires which enabled us to study pain using a numeric rating scale (NRS) of 0–10, function scores (using a WOMAC osteoarthritis index and a modified Harris Score [15]), as well as a satisfaction score using a NRS of 0–10. Late postoperative complications were also recorded.

Radiographical evaluation: All patients underwent immediate postoperative antero-posterior (A-P) X-rays of the pelvis before leaving the operating theatre (looking for perioperative complications) as well as early postoperative X-ray assessment (supine A-P view of pelvis, A-P and lateral view of hip). We were thus able to examine A-P and lateral view of stem positioning, abduction angle of acetabular cup and centring of the cup using the method of Pierchon et al. [21] (considered to be good when the difference between the theoretical value and the measured value is less than 5 mm, fair between 5 and 10 mm and poor over 10 mm). Measurement of the acetabular version was not carried out because of the great imprecision due to the presence of the metal back.

All analysis of the clinical, biological and radiographical data was carried out by a single observer (J.M.L.). Statistical analysis was carried out using Statview. Pre- and postoperative continuous variables were compared using a matched bilateral Student's *t*-test when distribution of values was normal. When this was not the case, a non-parametric Wilcoxon test was used. Continuous variables between the two groups were compared using a non-matched bilateral Student's *t*-test or a Mann-Whitney *U*-test. For nominal variables we used a chi-squared test, and an exact Fischer-Yates test when expected theoretical figures were lower than 5. A P value <0.05 was considered to be significant.

Results

All operative data are summarised in Table 2. Duration of operation was significantly longer in the anterolateral mini-invasive approach group at 79.5 min (55–150) in comparison with 71 min (45–140) in the posterior approach group (P=0.045). Pre- and postoperative biological parameters were comparable between the two groups, as was the very low rate of transfusion in our series. However, total blood loss after surgery was lower in the posterior mini-invasive approach group at 450±219 (26–937), in comparison with 537±197 (106–920) for the anterolateral mini-invasive approach group, at the limit of significance (P=0.07). By considering a haematocrit rate of 42%, this represents a total blood loss equal to 1071±521 (62–2,231) for the posterior approach, compared with 1279±470 (252–2,190) for the anterolateral approach.

Positioning of the implants was satisfactory in both groups. The abduction angle of the cup was significantly greater in the anterolateral group (P=0.02). Discrepancy in leg length was comparable in the two groups. It should be noted that in the anterolateral group, two patients presented postoperative discrepancies of 25 and 33 mm, respectively, who then underwent contralateral arthroplasty which enabled satisfactory correction.

We noted significantly more perioperative complications in the anterolateral group, with nine complications in nine patients: four fractures of the greater trochanter, three false routes during rasping (recognised and corrected perioperatively), and one calcar fracture during reduction of the final implant, which caused us to change a cementless stem for a cemented stem of the same model. The Omnicase (Zimmer, Centerpulse) stem comes in both cemented and

Table 2 Operative and biological data. The values are given as the mean and the standard deviation, with minimum and maximum

	ALMI group	MIP group	*P*
Duration of surgery (min)	79.5 (55–150)	71 (45–140)	0.045
Haemoglobin concentration (gr/dl):			
– preoperative	14.2±1.2 (12.3–16.6)	14±1.3 (11–16.6)	0.52
– D_5	10.4±1 (8.1–12.5)	10.7±1.3 (7.9–13.2)	0.3
Haematocrit rate (%):			
– preoperative	42.7±3.4 (37.2–51.3)	41.7±3.9 (33.0–49.1)	0.41
– D_5	31.7±3.1 (24.7–37.8)	32.4±3.7 (25.3–40.8)	0.53
Transfusional data:			
– Number of blood unit transfused (unit)	0.17±0.57 (0–2)	0.28±0.8 (0–3)	0.80
– Number of patients transfused	3/35	5/43	0.66
Calculated global globular loss (mm)	537±197 (106–920)	450±219 (26–937)	0.07
Operative complications	4 fractures of the greater trochanter, 3 false routes, 1 fracture of the calcar et 2 bascules of the acetabular cup	1 fracture of the lateral cortex	0.003
Implant positioning:			
– Abduction angle of the cup (degrees)	51.2±7.9 (38–72)	46.5±6.2 (34–60)	0.02
– Cup centring (good/fair/poor)	25/10/0	28/13/2	0.42
– Stem centring (degrees)	−0.03±2.4 (−8–5)	0.7±1.9 (−3–6)	0.18
Limb length discrepancies (mm):			
– Preoperative	−3.6±7.9 (−16–25)	−2.3±6.8 (−30–8)	0.16
– Postoperative	1.2±7.5 (−7–33)	1.6±7.1 (−14–21)	0.29

cementless varieties, and the fitting equipment is identical. One case of displacement of the acetabular implant underwent repeat surgery. We found acetabular labrum incarcerated behind the metal-back. In the posterior mini-invasive approach group, we found only one fracture of the external cortical bone in a female patient with a history of varus osteotomy.

During the postoperative period, in the anterolateral mini-invasive approach group, we found three haematomas, and repeat surgery was done on D_5 for one patient with displacement of an acetabular implant after weight was put back on the leg. In the posterior mini-invasive approach group, four haematomas and one distal venous thrombosis without complication were found. No infection was diagnosed. Postoperative pain was comparable between the two groups, as was length of hospital stay and type of discharge. In terms of functional outcome there was no significant difference between the two groups at 6 weeks, 3 or 6 months. At 6 months, one third of patients in both groups presented with a slight limp, and four patients out of 35 in the anterolateral mini-invasive approach group compared with only one out of 43 in the posterior mini-incision group required a walking aid. Overall, the patients in both groups were satisfied with the operation in comparable fashion. All postoperative clinical data are summarised in Table 3.

Discussion

There has been renewed interest in the approaches used for THRs over the last few years, with the emergence of what has been called mini-invasive surgery. However, prospective and comparative studies analysing the results of the mini-invasive approaches in comparison with established approaches are few and far between, and only two randomised studies have been published to date [7, 19]. As far as the authors know, there is no study comparing the results of two types of minimally invasive approaches with each other. And no study has analysed the results of Bertin and Röttinger's anterolateral mini-invasive approach. We therefore carried out a prospective and comparative study. No patient was selected for criteria of weight or of BMI [7, 12]. We did not randomise, but the two groups we studied were comparable preoperatively and all patients were operated on by the same surgeon and they were not aware to which group they belonged. Assessment was undertaken by an investigator (J.M.L.) other than the surgeon. Ques-

Table 3 Postoperative data and early clinical results. The values are given as the mean and the standard deviation, with minimum and maximum (*NRS* numeric rating scale)

	ALMI group	MIP group	*P*
Morphine-type analgesics used (mg)	22.2±34.5 (0–182)	16±13 (0–45)	0.31
Length of hospitalisation (days)	9.3±3.2 (5–24)	9.9±2 (7–15)	0.36
Discharge (Home/rehabilitation unit)	18/17	22/21	0.99
Clinical results at 6 weeks			
– Pain (NRS)	1.2±0.6 (0–2)	1.6±1.7 (0–5)	0.48
– Modified Harris Hip Score	80.1±13 (50–100)	78±18 (37–100)	0.66
– WOMAC osteoarthritis index	86.7±7.5 (75–99)	82.3±13 (42–100)	0.22
Clinical results at 3 months			
– Pain (NRS)	1.1±1.1 (0–3)	1.2±1.2 (0–5)	0.65
– Modified Harris Hip Score	88.5±10 (63–100)	84.5±12.4 (42–100)	0.23
– WOMAC osteoarthritis index	88.6±7.6 (70–100)	89±11.2 (39–100)	0.88
Clinical results at 6 months			
– Pain (NRS)	0.6±1.2 (0–5)	0.9±1.4 (0–5)	0.42
– Modified Harris Hip Score	90.1±11.7 (55–100)	89.7±12.3 (56–100)	0.91
– WOMAC osteoarthritis Index	89.6±11 (57–100)	91±12 (53–100)	0.55
Walking aid (number of patients)	4/35	1/43	0.12
– Limping (number of patients)	11/35	14/43	0.99
– Satisfaction (NRS)	8.9±1.6 (5–10)	9.2±1 (6–10)	0.42

tionnaires including established scores were used, which prevented any bias caused by the operating surgeon's interpretation.

In the Bertin and Röttinger approach [5], the intermuscular interval between the tensor fascia lata and the gluteus medius is used. The outcome should be excellent, in theory, because all the muscles are left intact: abductor muscles (gluteus medius and gluteus minimus), tensor fascia lata, and short external rotators. Jerosch et al. [13] propose an anterolateral mini-invasive approach carried out with the patient in a supine position. This approach passes between the fibres of the tensor fascia lata. They dislocate the hip by traction, adduction and external rotation before cutting the neck. In our experience, anterior dislocation is difficult and sometimes requires considerable, potentially risky, effort. They did not, however, note any perioperative fracture of the femur [13]. We did not meet with any such perioperative femoral fractures, because it is possible to cut the neck in situ, if necessary, before dislocating. However, we did note a much higher rate of perioperative complications in the anterolateral mini-invasive group than in the posterior mini-invasive group. Moving from the posterior mini-invasive approach to the anterolateral mini-invasive approach meant a new learning curve. The anterolateral mini-invasive approach requires significant adaptation by the surgeon who routinely uses a posterior approach. It means a change in landmarks in the reduced space available and in manoeuvres for exposure (in particular the placing of retractors). This has been the cause of fractures of the greater trochanter, which occur all the more readily when patients suffer from osteopenia, or very stiff hips, and the neck cut runs over into the greater trochanter. However, the reasons for repeat surgery in our study were two cases of early mobilisation of cementless acetabular cups for large heads out of 35 implants. In these two cases, we found residual labrum incarcerated behind the metal back, but this has little to do with the approach per se. In their study, Amstutz et al. [1] found two cups out of 54 primary total hip arthroplasties with large heads implanted using the standard posterior route which required very early repeat surgery after dislocation of very vertical cups. Positioning of the metal back is more vertical in the anterolateral mini-invasive approach, but that is due to the choice of implant, which is different to that used in the posterior mini-invasive approach.

Blood loss is lower during the posterior mini-invasive approach. This is explained by a longer operation time and by the effect of ligaturing the medial circumflex artery of the thigh [8] in the minimally posterior approach. Last of all, some muscular fibres of the tensor fascia lata can be cut by the oscillating saw during the cut of the neck of the femur with a significant postoperative bleeding in the drains.

Early clinical results obtained with the ALMI approach were very satisfactory and as good as those obtained using the posterior mini-invasive approach in our study, or as those obtained by Jerosh et al. [13], where an average Harris Score of 90.8/100 at 12 months was found. The results of operations using the posterior mini-invasive approach in comparison with standard posterior approaches have now been reported in a number of articles [7, 18, 19, 24]. This technique showed a decrease in peerioperative blood loss [7, 12, 18, 19, 22], but only Di Gioia et al. [10] used fewer blood transfusions. Some authors also indicated more rapid recovery after the posterior mini-invasive approach in comparison with standard posterior approaches.

Di Gioia et al. [10] found better early results for the Harris Hip Score at three and six months, and less cases of limp at six months. Chimento et al. [7], as with Sculco et al. [22], also found more rapid disappearance of postoperative limp. However, not all the authors confirm these results: Nakamura et al. [18] found no significant difference at six months, and Ogonda et al. [19] and Woolson et al. [24] found no difference at six weeks. With the exception of Woolson et al. [24], the complication rate did not increase during the posterior mini-invasive approach and the positioning of implants was comparable [7, 18, 19, 22] with respect to the standard-incision posterior approach.

The direct anterior mini-invasive approach [23] is an anatomical route which uses intermuscular and internerve tissue plains. Its results are attractive in terms of clinical outcome and dislocation rates [23]. It is used by a number of teams [17, 23] but is still not widespread because it requires an orthopaedic table to ensure proper exposure of the leg and hip elements to avoid requiring a separate incision [14] to work on the acetabulum or the femur, as is done in the two-incision approach [4]. The two-incision approach, made popular by Berger [4], offered advantages: monitoring the positioning of acetabulum and length of the lower limbs using an image intensifier during the operation. However, it also quickly showed its limits, with the lengthy learning curve, and sometimes serious complications [2, 11], in addition to not being able to implant cemented femoral stems. A recent study of cadavers [16] showed muscular damage during the use of this approach. In all the specimens there was damage to the gluteus medius and/or the short external rotators during the operations using the two-incision approach, whilst in the posterior mini-invasive approach group there were significantly less cases of damage to the gluteus medius.

Conclusion

Despite the learning curve required to master the antero-lateral mini-invasive approach, our study found early functional results in patients treated using this approach comparable to those using the posterior mini-invasive approach. The clinical results obtained were also comparable to those of other series of total hip replacements implanted using minimally invasive techniques. There was greater blood loss, but this was associated with a longer operating time. Positioning of the implants was comparable. Thus, once the learning period is passed, and a more standardised procedure achieved, surgeons should hope to obtain better results in patients operated on using the anterolateral mini-invasive approach, with a decrease in complications and in perioperative blood loss.

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