

Anterior and antero-lateral mini-invasive approaches for primary total hip replacement

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Abstract. *Background and aim of the work:* the literature provides conflicting data regarding the various approaches for hip prosthetic surgery. This study analysed our case series on the anterior and anterolateral minimally invasive approaches, trying to define the indications, complications, the technical tips, the advantages and disadvantages. *Methods:* from 2011 to 2019 we performed 1227 interventions of which 1020 had a regular follow-up, up to an average period of 5.1 years. 625 anterolateral and 395 anterior approaches were performed, of which 149 with longitudinal incision and 246 with an oblique “bikini” incision. *Results:* the Harris Hip Score showed similar results in the two groups, except from the early post-operative period, which showed slight superior results for the anterior approach. Surgical times were in favour of the anterolateral approach, while hospitalization times were less for the anterior approach. With the anterior approach, we recorded a greater number of complications, in particular malpositioning, periprosthetic fractures and neurological injuries, especially in the first two years of experience. *Conclusions:* there was no clear superiority of one approach over another. We conclude that the surgeon should know both techniques, to be adapted to the type of patient in consideration of the size and deformity. The traction bed provides more disadvantages than advantages, and in our experience it is not recommended. (www.actabiomedica.it)

Key words: hip; arthroplasty; replacement; approach; mini-invasive; anterior; anterolateral

Introduction

Hip prosthetic surgery is one of the most frequent procedures in orthopaedic surgery, with more than 1 million total hip replacements for year worldwide (1). The indications are increasing due to the lengthening of life prospects, the high functional demands even in the elderly patient, as well as the use of prosthetic replacement even in the young patient in relation to the outcomes of deformity or trauma.

The need to ensure rapid and full functional recovery has led over time to increasingly less invasive techniques, whose advantages and disadvantages were extensively studied, but far from defining which is the most reliable technique from the point of view of recovery times, final results and the risk of complica-

tions. In fact, most of the experts agree that a surgeon must choose the approach that he deems most suitable based on the type of patient and his technical background (2,3).

In the USA, according to the Kaiser Permanente Total Joint Replacement Registry (4), in the period 2001 - 2011, out of a total of 42,438 interventions, the most used surgical approaches were:

- 75% postero-lateral (PL) also called Moore or “southern” approach
- 10% antero-lateral mini-invasive surgery (ALMIS) evolution of the Watson-Jones (5)
- 4% anterior mini-invasive surgery (AMIS) evolution of the Smith-Petersen (6)
- 2% direct lateral approach (DLA) also called “trans-gluteal” or Hardinge approach (7)

This case study does not reflect the global preferences of surgeons, varying them according to the prevailing culture in individual regions of the world.

Despite satisfactory results in 89-95% of cases (3), this amount of interventions brings a considerable number of complications, with all the problems and costs related to their management. The most frequently reported complications in the literature are delayed wound healing, infections, DVT, neural damage, dislocation, periprosthetic fractures (8,9).

More specifically, the overall complication rate after hip replacement was reported at 6.9%, with 1.7% deep infections, 1.7% periprosthetic fractures, 1.6% wound problems, 0, 9% dislocations (10).

If we analyse the results and complications by type of surgical approach, we find discordant data, depending on the surgeon's experience, the different techniques used, and the systematic use of cementation in some countries. The different prosthetic models also affect the results of the intervention, so that the type of implant must also be evaluated in relation to the surgical approach, with the anatomical stems preferable when using minimally invasive anterior approaches (11).

As mentioned, the literature provides conflicting data on the different types of approaches. We have therefore analysed our case studies on the ALMIS route, which in our opinion represents an optimal choice for those who are already experienced with DLA. In fact, the patient is positioned supine, and the surgical interval is between the gluteus medius and the tensor fascia lata, resulting in easy convertibility to DLA in case of difficulty. We compared this type of approach with the AMIS, performed however without a traction bed, and therefore with some advantages, such as less difficulty in exposing the femur, better leg length control, less presence of health personnel around the surgical field for manoeuvres on the operating bed.

Materials and Methods

Patient population

From January 2011 to December 2019, 1227 hip prosthesis with mini invasive approaches were performed at the Riccione-Cattolica Hospitals (AUSL of

Romagna), at the ISS of the Republic of San Marino, and at the Malatesta Novello Clinic in Cesena. 745 of these were ALMIS approaches and 482 were AMIS. Of the latter, 184 were made with a longitudinal incision, the remaining 298 with an oblique incision better known as the "bikini" approach.

There were 1040 patients (187 bilaterally operated, of which 6 in the same operating session), 676 females and 364 males, with an average age of 71.2 years. Of these patients, only 872 were followed up with clinical and radiographic checks at regular intervals, for a total of 1020 interventions, divided into 625 ALMIS, 149 AMIS with longitudinal incision, 246 AMIS with "bikini" incision.

The surgical time was recorded for each patient, as well as the days of hospitalization.

Pre and post-operative x-rays were used to evaluate malpositioning in relation to the intervals recommended by the literature (12). Clinical and radiographic follow-up was performed in the pre-operative and then at 3 and 12 months, as well as at the final follow-up, with evaluation by Harris Hip Score.

The indications for prosthetic replacement were distributed as follows:

- 691 primary coxarthrosis
- 107 post-traumatic coxarthrosis
- 104 osteonecrosis
- 82 outcomes of dysplasia
- 36 outcomes of Perthes or epiphysiolysis

Surgical Techniques

ANTEROLATERAL MINI-INVASIVE SURGERY (ALMIS): We used a standard surgical table without traction, including only one limb in the surgical field. The table can be broken at the level of the hip joint to hyperextend both legs. The patient was positioned in a supine position on the outer edge of the operating table. Anterosuperior iliac spine (ASIS) and greater trochanter (GT) were the most important landmarks. The skin incision was centred anteriorly to the trochanter notch and extended for 7-10 centimetres (Fig. 1). Deep fascia was reached and incised in the same direction of the skin incision. Now the intermuscular space between the tensor fasciae latae (TFL) muscle and medium gluteus muscle was recog-



Figure 1. ALMIS incision lies longitudinally, anterior from the tip of the GT.

nized. Spreading apart with Hohmann's retractors the TFL medially and the medium gluteus laterally, the articular plane was reached (Fig. 2). We carried out anterior capsulotomy to expose the femoral neck and proceeded with in situ femoral neck osteotomy (Fig. 3). The femoral head was removed and the Hohmann retractors positioned. Care was taken to use a forked lever with short and blunt tips in the posterior part of the acetabulum to lower the proximal femur (Fig. 4).



Figure 2. In the ALMIS approach the articular plane is reached between TFL and gluteus medius.



Figure 3. In situ femoral osteotomy is performed and the femoral head removed.

Standard acetabular reaming was performed first, using offset reamers. For the femoral canal preparation, we usually hyperextended, adducted and externally rotated the operated leg, under opposite leg. Posterior capsular release on the proximal femur was subsequently performed. We positioned a Hohmann retractor under the GT to raise up the femur, and another retractor in the calcar area to retract the medial soft tissues. Femoral reaming was performed in a standard fashion.

ANTERIOR MINI-INVASIVE SURGERY (AMIS): We used the same surgical table and patient positioning as in the ALMIS approach. Important landmarks in the AMIS approach were the ASIS and GT. From the ASIS we measured 2 inches laterally and 2 inches distally to find the midpoint of the skin incision. From the midpoint, a 7-10 centimetres skin incision may be developed longitudinally (Fig. 5), or obliquely along the inguinal fold for the "bikini" approach (Fig. 6). In this latter case, a suture was positioned in the medial part of the skin incision to avoid involuntary spreading of the incision, which could expose the lateral femoro-cutaneous nerve, which lies subcutaneously upon the sartorius muscle. The tensor aponeurosis was reached and incised in the axis of the TFL muscle (Fig. 7), which was then separated from the aponeurosis and spread apart laterally with a spatula, with the Sartorius muscle spread medially. Now two Hohmann retractors were inserted exposing the joint capsule, taking case



Figure 4. A forked lever with short and blunt tips is used in the posterior part of the acetabulum.



Figure 5. Longitudinal AMIS incision centred 2 inches lateral and 2 inches distal from the ASIS.



Figure 6. The AMIS “bikini” oblique incision is centred 2 inches lateral and 2 inches distal from the ASIS, and follows the inguinal fold for 7-10 centimetres. Care is needed not to damage the LFCN in the medial part of the skin incision.

to avoid sharp edge levers. Self-retaining retractors were not used. The first was placed between the psoas and the anterior capsule. The second was placed between the superior joint capsule and the gluteus minimus. Before

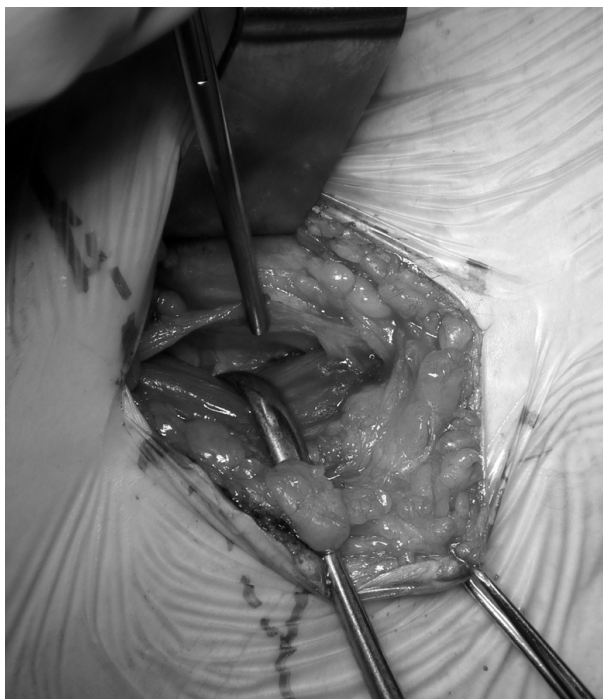


Figure 7. The tensor aponeurosis was incised in the axis of the TFL muscle, which was then separated from the aponeurosis and spread laterally.

proceeding with capsulotomy it is important to identify the ascending branches of the lateral circumflex artery (Fig. 8), which must be cauterized or sutured. Capsulotomy was then performed. Subsequent steps were the same that in the ALMIS approach.

Implants

All cups were press-fit, with stabilization screws in 6 cases. T-Pore (Adler), R3 (Smith & Nephew), Delta-PF and Delta-TT (Lima), Jump System (Permedica) were used. 437 were straight stems: Polar stem (Smith & Nephew), H-Max (Lima), Exacta S (Permedica). In 338 cases, a Hydra modular neck stem (Adler) was used. Anatomical stems have never been used. In the remaining 245 cases, a monoblock mini-stem was used, of which 211 were neck-preserving (Nanos - Smith & Nephew and ColloMis - Lima), and 34 without neck preservation (Minima - Lima). Cemented components have never been used.



Figure 8. In the AMIS approach, it is important to identify the ascending branches of the lateral circumflex artery before proceeding with capsulotomy.

Post-operative treatment

All patients had a surgical drain removed the day after surgery. On the same day of the surgery, the patient was invited to actively mobilize the ankle, to perform isometric contractions of the quadriceps, to actively flex the operated hip. The sitting position was assumed on the first day, on the second day the standing position and walking with a walking trolley, and with crutches on the fourth day. The patient was discharged when already autonomous with crutches, also for the stairs.

The timing could undergo variations in relation to prolonged drainage, significant post-operative anaemia, poor pain control, advanced age, comorbidities that advised against early mobilization.

Our protocol envisaged, for both the approaches studied, to walk with two supports for 2 weeks, then to start walking with only one support on the healthy side. One month after the operation, people started walking without support.

From 2013 to 2019, in a total of 734 cases, the post-operative protocol for the prevention of periprosthetic ossification with celecoxib was applied.

Results

Follow-up was 1-9 years, with a mean of 5.1 years.

The mean surgical time was 61 minutes for the ALMIS approach and 75 minutes for the AMIS approach.

The mean hospitalization was 5.5 days for the AMIS approach and 6.4 days for the ALMIS approach.

The average clinical results obtained with the Harris Hip score are shown in Table 1.

Cup malposition occurred in 1.8% of cases with the ALMIS approach and in 3.2% of cases with the AMIS approach. However, these percentages have seen a tendency to decrease over the course of the se-

Table 1. Clinical results with the Harris Hip Score

	Pre-op	3 months	12 months	FU
AMIS	49,7	89,1	92,5	92,3
ALMIS	46,3	84,5	92,8	92,5

ries. The varus malpositioning of the stem (1.2%) did not show significant differences in the two different types of approach.

Periprosthetic fractures occurred in 1.4% of cases. Five patients had a detachment of the apex of the GT, while in one case a massive intertrochanteric fracture was observed (AMIS on a patient with advanced osteoporosis). In the detachments of the apex of the GT, no osteosynthesis was adopted, as the fracture did not affect the insertion area of the gluteus medius and therefore no functional impairment of walking was observed. The five patients affected by this complication only complained of pain during early re-education following the surgery, without affecting the final result. In the case of the massive intertrochanteric fracture, an osteosynthesis with a modelled plate was performed, simultaneously with the prosthesis, with a decrease in the final score, compared to the average of the patients.

After using a neck-preserving mini-stem there were 6 fractures in the calcar or femoral neck that required a metal cerclage, without affecting the post-operative course or the final result.

In two cases we reported the fracture of the proximal metaphysis of the femur. In the first of the two cases, the diagnosis was made intraoperatively, and therefore the treatment consisted in the cerclage of the fracture and in delay of weight bearing. In the second case the diagnosis was late, and a second intervention was therefore needed to replace the primitive stem with a revision stem, with the application of metal cerclages, using an enlarged DLA.

In one case, the mini-stem was replaced, again through the same ALMIS approach, due to the sinking of the stem observed in the immediate post-operative period. We also observed two cases of early cup loosening, apparently well positioned in the post-operative control. In one case, again through the minimally invasive way, the cup was replaced. In the second case, the cup had become horizontal, but there was a secondary osteointegration, for which the patient was not subjected to revision as he became asymptomatic.

We observed four cases of sciatic paralysis, all in the first 3 years of experience with minimally invasive routes. Two cases were subjected to revision of the sciatic course by the neurosurgeon, and in both cases, an imprint was highlighted on the sciatic trunk posterior

from the acetabulum, probably in relation to the use of a lever with a long tip. Eliminating the use of the Hohmann lever to lower the femur and instead using a forked lever with short and blunt tips, we have no longer found the incidence of this problem.

A transient neuroapraxia of the lateral femorocutaneous nerve (LFCN) occurred in 3 cases operated with AMIS and “bikini” incision. There were two lesions affecting the femoral nerve, one in case of AMIS longitudinal approach, and one after ALMIS approach. Both showed an incomplete regression.

We reported only one case of dislocation, which was then manually reduced and no longer relapsed.

Cases of deep infection using minimally invasive approaches were extremely low in our case series. Only four patients needed implant removal and two stage revision.

In 6 cases we reported superficial infections, three of which were treated with surgical debridement. In none of these six cases was it necessary to remove the prosthetic implant.

With the AMIS approach, in about ten cases we reported the formation of uninfected seromas, four of which required syringe aspiration. In the other cases, the seroma resolved spontaneously with the use of anti-oedema, steroids, NSAIDs, cryotherapy.

Heterotopic ossifications were drastically reduced after the systematic introduction of celecoxib prophylaxis. In fact, we found 17.6% of ossifications in the first two years of the series, reduced to 1.5% in the second part (Brooker grade I-II).

Discussion

In our experience, the use of minimally invasive approaches resulted in better clinical results compared to traditional techniques, especially during the early post-operative period. The most surprising data relates to the lower post-operative pain that determine a lower intake of drugs and an earlier resumption of autonomous walking without crutches, which in almost all cases was allowed after one month from surgery. This translates into a shorter length of hospital stay.

According to our case series, the AMIS and ALMIS approaches did not provide different results

in the long term, but in the short term, the AMIS provided better results, so that recovery was faster, we believe in relation to the gluteus medius retraction required in the ALMIS approach. Less energy applied in the gluteus medius retraction can lead to a faster recovery, and this can be achieved after an adequate learning curve. Even in cases operated with AMIS, both with bikini and longitudinal approach, great attention must be paid to the use of the levers that lower the tensor of the fascia lata. It is preferable to use levers with bevel edges, which reduce the mechanical stress on the muscle bundle. The use of sharp edge levers can lead to a tear in the tensor muscle fibres, resulting in post-operative pain.

In our series, the AMIS technique showed a slightly longer operating time, but a shorter average hospital stay. The literature agrees on the shorter recovery and hospitalization times with AMIS approach, but it also emphasizes a higher rate of wound problems, infections, periprosthetic fractures, failures (10,13-24). In our case series we also had a higher rate of wound problems, seromas and superficial infections in AMIS, in particular with the "bikini" incision. The explanation of this complications lies in the reduced thickness of subcutaneous tissue in the anterior part of the thigh, in the use of this approach in obese patients with abdominal protrusion upon the wound, as well as in the use of the traction table with increased staff involved in the operating room, the latter not used in our series (4,24-26). The higher rate of failures reported by the literature after AMIS, on the other hand, seems to be linked to the greater difficulties in positioning the implant (4,27,28). Our case series also confirms the greater number of malpositioning of the cup after AMIS approach, especially in the first years of experience, linked to the more difficult visualization of the cup.

The literature reports that periprosthetic fractures occur more frequently in the GT and with the AMIS approach, in relation to the difficulty of exposure of the femur, especially with the use of the traction bed (3,4). Another disadvantage of the traction bed is the difficulty in controlling the leg length (29). In our case series, periprosthetic fractures had an overlapping incidence in the two approaches, meaning that the difficulties in exposing the femur were similar. For a better

exposure of the femur it is helpful to lower the distal part of the bed and extend the hip.

The incidence of dislocation is debated in the literature, with most studies finding a higher rate of dislocation with posterior approaches (2-4,10,30-38). Dislocation after posterior approach appears to be less frequent if capsular repair techniques are used (3,34,39-41). In our case series, the dislocation was an exceptional event.

Another frequent complication is represented by heterotopic ossifications, which occur in 28.4-30% of cases in the literature (29,42). These appear to be more frequent after mini-invasive approaches than DLA, probably as a consequence of the muscle strain trauma. Limiting traction on the muscles during surgery, using levers with bevel edges and introducing post-operative pharmacological prophylaxis, are factors that have contributed to limiting the incidence of this complication in our cases.

The most frequent (but often transient) neurological lesions, are those affecting the LFCN, and occur with anterior approaches in 3.4-8.1% of cases in the literature (3,43-45). Femoral nerve is involved in 0.1-1.7% of cases (3,46-48), while sciatic lesions are related to posterior approaches (3,46). Our experience confirmed the great importance of the correct use of the levers when exposing the acetabulum.

We have not noticed substantial changes between standard and minimally invasive approaches, as regards bleeding and postoperative anaemia, given that most of the blood loss derives from femoral resection and cup reaming. It is clear, however, that a less extensive field leads to less bleeding from the soft tissues. On the other hand, no differences in blood loss were found between ALMIS and AMIS.

The weakness of the present study was in its descriptive nature, and in the lack of a statistical analysis of the results. The paper evaluated advantages and complications of AMIS and ALMIS mini-invasive approaches, as described in our case series. A comparison of these two techniques with the direct lateral approach was based upon our personal experience and upon the literature review.

Ultimately, which type of minimally invasive approach to choose? In our opinion, the surgeon should have in his hands all the surgical techniques that can

be performed in the supine patient, in order to be able to adapt them to the specific case.

For example, the “bikini” approach, which of the three could be the most difficult to perform, should be reserved for thin women with no particular joint deformities. In fact, in these cases it is much easier to perform the surgery correctly with an aesthetic advantage, with a reasonable safety margin.

The straight AMIS approach finds its place in all cases where mini-invasiveness is applicable, with a particular recommendation in women who have conspicuous posterolateral adiposity. In the anatomical area between the sartorius and the tensor there is usually not abundant adipose tissue and therefore the approach is less demanding than a minimally invasive antero-lateral one, where it becomes necessary to spread a greater amount of soft tissue.

ALMIS can also be used in all cases where there is an indication for minimally invasive. This approach is very useful in post-traumatic cases or with more severe articular deformities, when in case of difficulty it is possible to easily transform the approach from minimally invasive to DLA.

The major advantage of DLA seems to lie in the shorter surgical time (10), albeit with the disadvantage of residual weakness affecting the gluteus medius (2,29). A 2017 study states that DLA provides superior final results than the others. According to the study, the AMIS approach is burdened by the major complications, while the lowest complication rate is obtained with the PL path. The study concluded that DLA represents the right compromise between results and complications, and that this approach is recommended, also in relation to the simpler positioning of the patient and the speed and simplicity of the technique, especially for surgeons who have recently approached this type of surgery (49). We agree but add that the ALMIS approach represents its natural evolution in a minimally invasive way. AMIS approach require a longer learning curve, so we don't recommend it for the beginners.

Conflict of Interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article

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