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Technical note

ALDI (Anterior Lateral Decubitus Intermuscular) approach to the hip: Comprehensive description of the surgical technique with operative video

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ABSTRACT

The direct anterior approach to the hip is judged to be difficult and even after many solutions, such as special operating tables, have been proposed to perform it, in some reports the complication rate remains high. The complications reported are nerve lesions, dislocation, muscles damages, intraoperative fractures. We describe a modification of the anterior approach, undertaken keeping the patient in lateral decubitus, in order to gain a better range of leg movement and a significant reduction of the force applied to the retractors, the technique was named ALDI (anterior lateral decubitus intermuscular) approach. The surgeon starts behind the patient as in all the other traditional approaches, to maintain unchanged the acetabular view and the dexterity in cup implantation. For the femoral preparation, he moves in front of the patient to have a better visualization. In a series of 150 patients, with a mean operative time of 51.38 minutes (range, 40–112), we had no intraoperative fractures, one (0.6%) lateral femoral cutaneous nerve temporary neurapraxia, one (0.8%) posttraumatic dislocation four years after the operation and, no revisions for aseptic loosening or infection. At the 5 years follow-up, the mean Oxford Hip score was 45.2 (range, 38–48; SD 2.6), the mean Harris Hip Score was 96,7 (range, 76–100; SD 2.8), and the mean UCLA score was 7 (range, 5–10; SD 1.4). The possibility to always obtain the optimal position of the surgical window with reduced tension on the muscles, and the unchanged initial surgeon position, could make the ALDI approach the ideal technique for the surgeons that decide to perform an anterior approach.

1. Introduction

The direct anterior approach (DAA) is considered a difficult approach, in order to minimize the problems associated with the technique, surgeons use special operating tables, for example traction tables [1], or tables that allow the lowering of one leg [2]. Not completely satisfied by our previous approach, the Hardinge, as it necessarily requires the sacrifice of muscles and tendons, we sought in the DAA the new direction for tissue sparing surgery. To reduce the laboriousness of the leg management associated to the supine position of the DAA, in January 2008 we have started to adopt the anterior approach keeping the patient in the lateral decubitus, naming it "ALDI (Anterior Lateral Decubitus Intermuscular) Approach" [3]. We use a standard table, with standard draping. The surgeon begins standing posteriorly (Fig. 1), as for the other traditional approaches: direct-lateral, posterolateral and anterolateral. He remains in this position until the cup is inserted, then he moves in front of the patient for the femoral preparation. Other authors have started to use the lateral decubitus, but they need always special tables with special draping, as for the Micro-Hip [4–8], and they stay always in front of the patient [9,10] (Table 1).

We recognize the well-documented advantages of the anterior approach in terms of patient recovery [11], but we also believe in the possible enhancements derived by the association of the lateral decubitus to it, as the lower blood loss in the lateral position compared to the supine [12], the reduced learning curve thanks to the previous experience with the patient's and the surgeon's position, the possibility to continuously manage the leg to gain the better surgical window and the lesser muscular tension.

2. Surgical technique

Place the patient in lateral decubitus near the posterior edge of a standard table.

The skin incision starts 2 cm lateral to the anterior superior iliac spine (ASIS) and extends distally for 8–10 cm in the direction of

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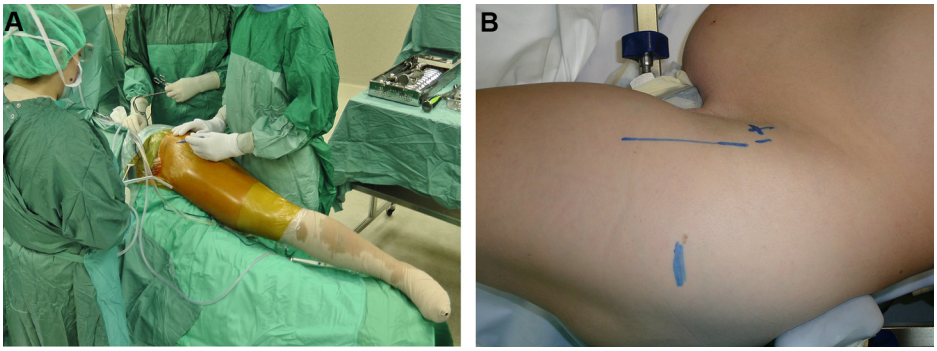

Fig. 1. A. The surgeon stands behind the patient with an assistant on his side and an assistant in front of the patient. B. The skin incision starts 2 cm lateral to the anterior superior iliac spine and extends distally for 8-10 cm in the direction of the Gerdy's tubercle.

Table 1
Papers related to anterior approach and lateral decubitus from PubMed, Scopus, and Web of Science.

Author	Period	Patients	Approach	Incision	Table	Surgeon position
Michel et al. [4,5]	NA	500	Micro-Hip	Neck axis	With only one leg holder	In front of the patient
Carta et al. [3]	Apr 2008–Oct 2009	168	ALDI	2 cm lateral the ASIS to the Gerdy tubercule	Standard	Back to the patient for acetabulum, in front for femur
Sendtner et al. [6,7]	Sept 2007–Oct 2008	60	Micro-Hip	Neck axis	With only one leg holder	In front of the patient
Melma net al. [8]	Oct 2009–Apr 2013	182	Micro-Hip	Neck axis	With only one leg holder	In front of the patient
Chen et al. [9]	Jul 2014–Dec 2014	126	NA	line from ASIS to the fibula	Standard	In front of the patient
Camenzind et al. [10]	Sept 2009–Nov 2011	138	NA	2 cm lateral the ASIS to the external border of patella	Standard with tunnel bolster	In front of the patient

NA: not applicable; ALDI: anterior lateral decubitus intermuscular; ASIS: Anterior Superior Iliac Spine.

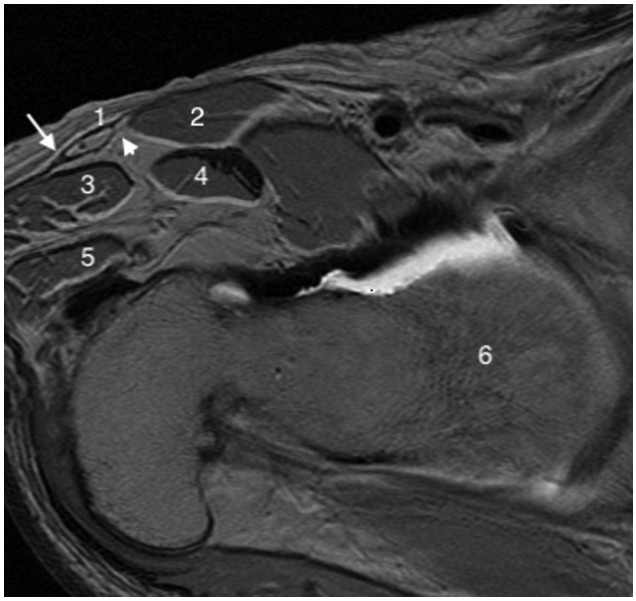

Fig. 2. Magnetic resonance of a right hip. 1 lateral femoral cutaneous nerve; Arrow: fascia lata; Arrowhead: iliac fascia; 2 Sartorius; 3 tensor fasciae latae muscle; 4 rectus femoris; 5 vastus lateralis; 6 femoral head.

the Gerdy's tubercle (Fig. 1B), its half-way point is centered on the tip of the greater trochanter (Video 1). Dissect the subcutaneous plane until the tensor muscle fascia is exposed and incise it. The lateral femoral cutaneous nerve (LFCN) runs downwards in a space between the fascia lata and the iliac fascia [13] (Fig. 2), and it's not usually visible. The nerve remains always deep to the fascia lata for the first 3 cm below the inguinal ligament, and its branches usually only reach the subcutaneous fascia at a mean distance of 95 mm distally from the ASIS [14]. However, extreme attention must be reserved for this phase because the branches' directions have high variability in the individual distribution in the proximal aspect of the thigh [15].

Isolate and retract the tensor fasciae latae muscle (TFL) posteriorly with a Charnley retractor and insert the Hosel retractor to protect the rectus femoris anteriorly. Cauterize the ascending branch of the lateral circumflex femoral artery and its veins that run under a thin fascia. During the dissection hold the leg in slight abduction, extension and external rotation.

Expose completely the capsule by dissecting the fat over it from the reflected tendon of the rectus femoris proximally to the muscle belly of the vastus lateralis distally. This belly, that arises from the anterior aspect of the upper femoral shaft, is recently named "tensor vastus intermedius muscle" [16]. Replace the Charnley retractor with the narrow curved Hohmann, and separate posteriorly the gluteus minimus from the capsule cutting the fibrous expansion between these two structures (Fig. 3A). The capsule is incised in an H shape line (Fig. 3B) and is detached distally under the vastus lateralis from the greater trochanter laterally, to the calcar medially in order to expose the neck completely (Video 2). The leg, held in a small amount of abduction, should be progressively externally rotated (Fig. 4A). Place the blunt Hohmann between the neck and the capsule, and move the narrow curved Hohmann anteriorly just over the acetabular anterior edge. With a Hosel retractor positioned inferiorly to pull and protect the vastus lateralis and the neurovascular bundle, proceed with the capsular release from the femur (Fig. 4B).

The visualization of the piriformis fossa is useful to determine, according to the preoperative planning, the height of the femoral

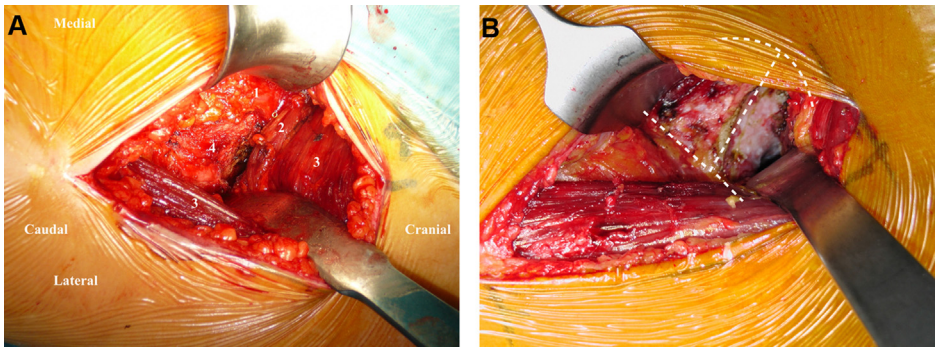

Fig. 3. A. The surgeon view: 1 reflected tendon of the rectus femoris; 2 gluteus minimus detached from the capsule (arrow); 3 tensor fasciae latae muscle; 4 hip capsule. B. The capsule is incised in an H shape line and is detached distally under the vastus lateralis from the greater trochanter laterally, to the calcar medially in order to expose the neck completely.

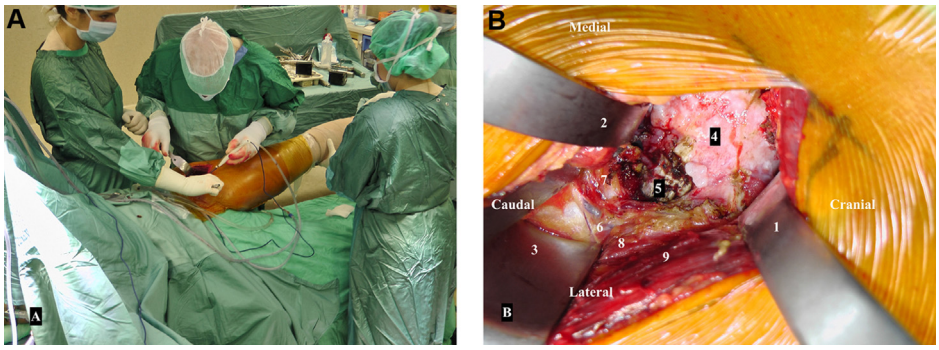

Fig. 4. A. Surgeon position during the capsular release. The leg is slightly abducted and progressively externally rotated. B. The detachment of the capsule and the iliofemoral ligament from the femoral neck. Surgeon view: 1 blunt Hohmann; 2 narrow curved Hohmann; 3 Hosel retractor; 4 femoral head; 5 femoral neck; 6 a branch of the femoral circumflex artery; 7 remaining hip capsule to be detached; 8 vastus lateralis or "tensor vastus intermedius"; 9 tensor fasciae latae muscle.

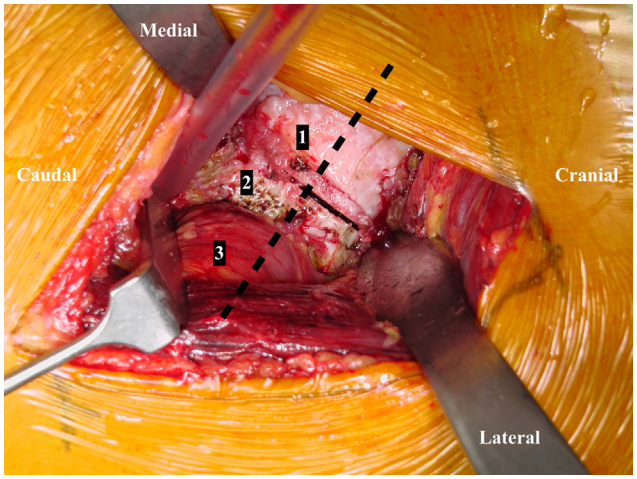

Fig. 5. Surgeon view: 1 femoral head; 3 femoral neck; 3 vastus lateralis or "tensor vastus intermedius"; dotted line: femoral neck axis.

neck osteotomy that should be perpendicular to the neck axis (Fig. 5). Exchange the Hohmann behind the neck with the Charnley retractor to protect the TFL during the femoral head removal, then move the leg into a figure of four position to complete the capsular release around the inferior-posterior edge of the resected neck (Fig. 6A, B). Return the leg to the original position of abduction, extension and external rotation, and replace the Charnley with the wide curved Hohmann positioned between the tendon of the gluteus minimus and the greater trochanter (Fig. 4A). Continue the capsular and the ischio-femoralis ligament release (Fig. 7), use a hook under the calcar to verify if the release is complete: if the femur moves anteriorly to the acetabulum, it is adequately released.

The acetabulum is exposed utilizing three Hohmann retractors (Video 3):

- wide curved Hohmann behind the posterior acetabular edge to retract the femur and the muscles
- narrow curved Hohmann behind the anterior acetabular edge
- blunt Hohmann under the acetabular notch, inferiorly

During the acetabular preparation (Fig. 8), the reamer should be oriented as the definitive cup planned position. Insert the acetabular implant in the appropriate amount of inclination and anteversion using the exposed pelvic bone landmarks (Fig. 9), then insert the liner. In normal acetabula, the cup inclination should follow the line between the acetabular superior edge and the acetabular notch. The correct cup anteversion is reached when the cup is parallel to the acetabular notch line, and to the line that joins the origin of the ischiopubic and ileopubic branches [17,18]. During the femoral preparation, the surgeon moves in front of the patient and the assistant goes to the back to hold the leg in extension, adduction and external rotation (Fig. 10A). Place a wide Hohmann behind the tip of the greater trochanter just under the gluteus minimus tendon. Place the extra leverage femoral neck elevator under the posterior part of the femoral neck. If a better femoral visualization is needed, as in cases with marked retraction of the short external rotators, it is possible to detach them from the posterior aspect of the femur (Fig. 10B). Use an offset canal finder before using a starter reamer or initial broach (Video 4). A double offset handle may help the femoral broaching requiring less tension over the retractor and the femoral elevator (Fig. 10C). Cortical bone of the posterior femoral neck and the inner profile of the calcar delineated

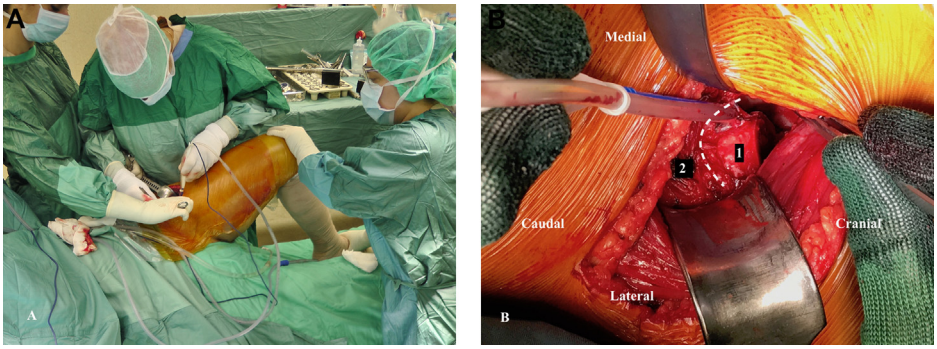

Fig. 6. A. The figure of four position. B. The detachment of the capsule, the pubofemoral and the inferior part of the ischiofemoral ligaments from the calcar. Surgeon view: 1 resected femoral neck; 2 vastus lateralis or "tensor vastus intermedius"; dotted line: direction for the release.

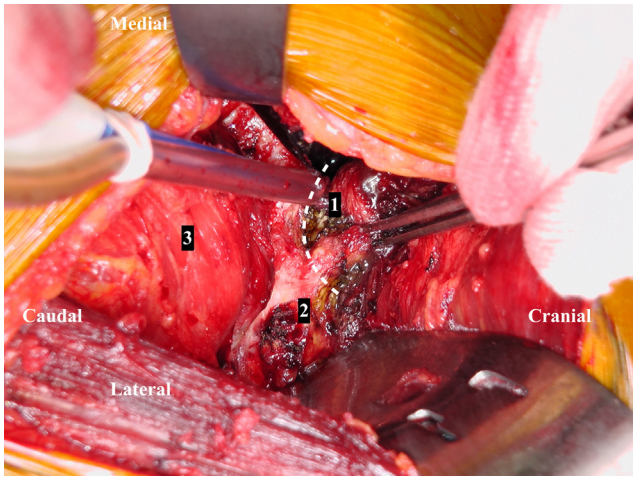

Fig. 7. Surgeon view: the detachment of the capsule, and the superior and posterior part of the ischiofemoral ligament (1) from the greater trochanter (2). Dotted line: direction for the release; 3 vastus lateralis or "tensor vastus intermedius".

Fig. 8. Surgeon position during the acetabular preparation. There's no need to apply any force to the leg that is just held in a neutral position.

by the lamina femoralis interna [19] guide the appropriate version of the femoral component. Progressively increase the broach size until it fills the femoral canal, then insert the definitive stem (Fig. 11).

The surgeon returns behind the patient for the trial reduction. Replace the Hohmann and the femoral elevator with the Charnley and the Hosel retractors. Reduce the hip with the trial head and test

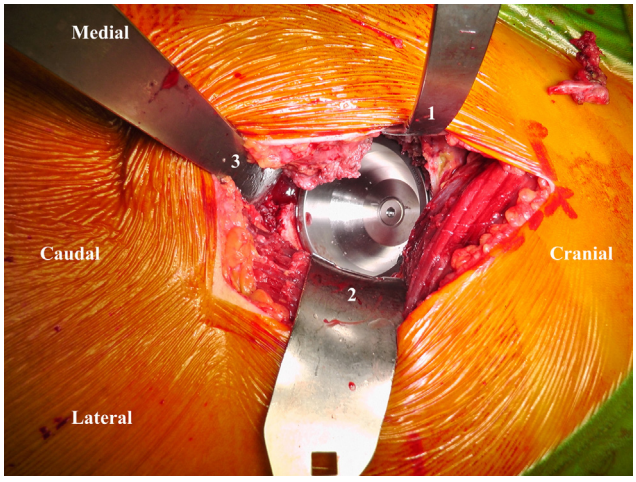

Fig. 9. Surgeon view: the implanted cup. 1 narrow curved Hohmann; 2 wide curved Hohmann; 3 blunt Hohmann under the acetabular notch.

the joint for soft tissue tension, impingement, anterior and posterior stability, then insert the definitive head. Suture the capsule with three stitches, then close the fascia, the subcutaneous tissue and the skin.

The pre-operative planning using radiographs with templates is always a paramount aspect of the surgery to help in the correct implant positioning (Fig. 12). We have not had the need of fluoroscopy during any our surgery.

3. Results

A retrospective analysis was performed on prospectively collected data on the first 150 patients who met the inclusion/exclusion criteria between January 2008 and December 2010, excluding the first 50 surgeries for the learning curve (Table 2 and Table 3).

All patients were managed with the same multimodal anaesthesia and analgesia protocol. Prophylactic antibiotics (cefazolin 1 g) were given 1 h before surgery and every 8 h for 24 h postoperatively. Patients routinely received anti-thromboembolic prophylaxis for 30 days postoperatively. All the patients, the day after the surgery, went to sit down independently and full weight-bearing was allowed with the use of crutches or a walker.

4. Discussion

When a surgeon becomes familiar with his reference points and repeatedly obtains good results with implant positioning it is hard to change his habit, requiring him to undertake a new

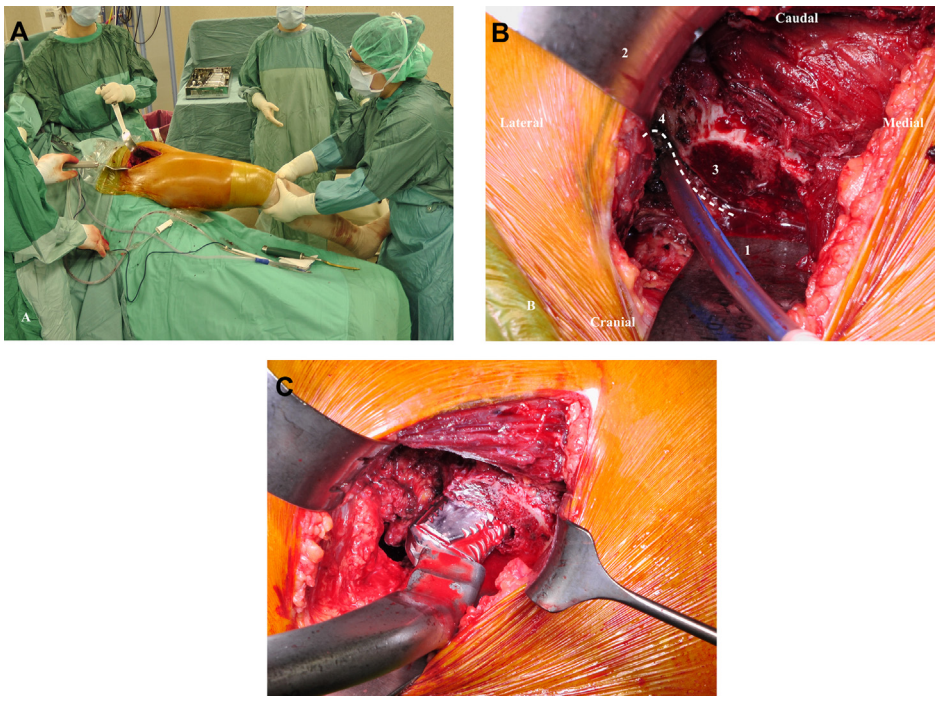

Fig. 10. A. Surgeon and assistants positions during the femoral preparation. The leg is adducted, extended and progressively externally rotated. B. Surgeon view: 1 extra leverage femoral neck elevator; 2 wide curved Hohmann; 3 femoral canal; 4 piriformis fossa; dotted line: direction for the release. C. A double offset handle may help the femoral broaching requiring less tension over the retractor and the femoral elevator.

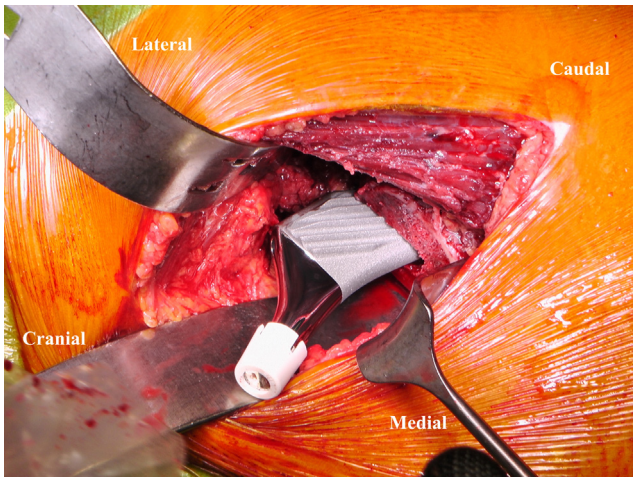

Fig. 11. The definitive stem insertion.

learning curve. Our background was with the direct-lateral approach hence, since our first experience with the ALDI, we did not have difficulties with acetabular exposure and cup positioning. Instead, a new learning curve is required in order to achieve the appropriate femoral exposure. Performing an optimal femoral capsular release is the key aspect of the entire surgery, so we pay the highest attention to this procedure, that occurs in four different phases. The first one is the detachment of the capsule anterior portion (Fig. 4A, B), while the second is the complete calcar release with the leg in the figure of four (Fig. 6A, B). The third phase is the most important one because, if the ischio-femoralis ligament is not completely detached from the trochanter (Fig. 4A and 7), the femur cannot be elevated and translated anteriorly. The fourth phase is seldom required, for instance in patients with marked external rotation contracture that need the short external rotators release (Fig. 10A, B). The possibility associated to the lateral decubitus to move the leg in all the directions helped us in all these phases, and during the femoral preparation, this wide range of movement permitted also to obtain easily the good alignment between the femoral axis and the anterior window. Instead in the supine position, it could be further problematic and not easy to simplify because the leg movements are limited by the operating table or constrained by the traction table.

The debate on DAA is still open (Table 4), and while some authors reported comparable results with the other approaches [25–27], others have reported a high rate of complications as LFCN lesions [28] and negative postural effects [29,30]. They ascribe these complications to the greater force applied from retractors to soft tissues or to the lesions of the femoral nerve branches to the TFL and quadriceps. To avoid this risk, we have reduced to the minimum the number of retractors used, two for most of the time, three only for acetabular preparation, and all of them are provided with blunt edges. We also take care not to damage the nervous and vascular branches for the thigh muscles (Fig. 4B) [31]. Moreover, in the supine position, the force required to elevate the femur, with the elevator that crushes the underlying TFL, gluteus medius and maximus, is much more of the force required in the lateral decubitus to translate anteriorly the femur.

Our study, which started at the very beginning of our experience with the ALDI, was designed to evaluate only aspects related to patient safety. It focused mainly on surgical procedure complications and didn't evaluate in depth the performance gained by the patients over time.

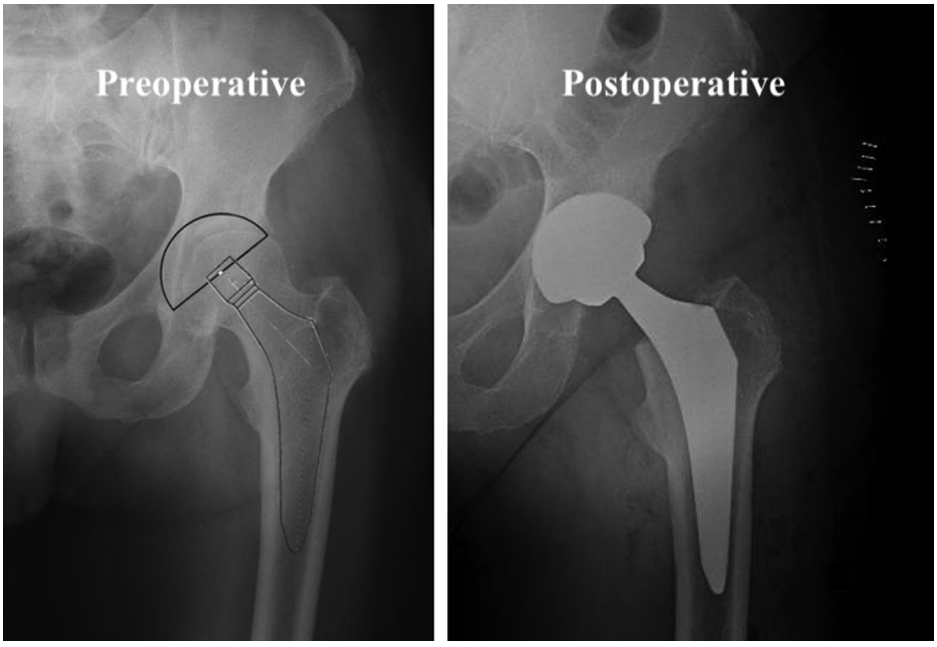

Fig. 12. Preoperative, with templating, and postoperative radiographs of the left hip of the patient showed in the video.

Table 2
Demographic data: The inclusion criteria were: age of 20 to 90 years, diagnosis of unilateral osteoarthrosis of the hip. Exclusion criteria included: diagnosis other than unilateral hip osteoarthrosis, patients undergoing bilateral THAs, femoral neck fracture, previous open surgery on/around the hip with or without presence of hardware, infection, neuromuscular disorders, inflammatory arthropathy, and other musculoskeletal disorders with potential to impede postoperative rehabilitation and weight bearing.

Patients	150
Completed the 2 years Follow-up	148
Completed the 5 years Follow-up	131
Lost during the study	16
Died	3 (for causes not related to surgery)
No. of women/men	84/66
Mean patient age (range), y	69 (41–88)
Mean BMI (range), kg/m^2	30,36 (20,4–39,1)
ASA score (1/2/3/4) [20]	46/73/31/0
No. of left/right surgeries	79/71

BMI: body mass index; ASA: American Society of Anesthesiologists.

Table 3
Results: blood samples were taken at the pre-, immediate postoperative, first, third and fifth postoperative day to assess haemoglobin. The total number of transfusion and the amount of unit transfused were counted to determine the blood loss. Clinical follow-up with radiographic analysis, Oxford Hip Score, Harris Hip Score and UCLA (University of California, Los Angeles) scale, was performed pre-operatively, immediate post-operatively, 6 months postoperatively and annually thereafter for 5 years. Values are expressed as mean (min-max; SD), and proportion.

Operative time (min)	51,38 (40-112)
Intraoperative complications (fractures, muscles or tendons lesions)	0
no. of allogenic blood unit transfused	32
no. of patient transfused	14 (9,3%)
Mean day of transfusion	3rd day
Hospital stay (days)	5 (4–9)
Early minor complications (150 patients)	Hematoma: 2 (1,3%) Superficial infection: 2 (1,3%) LFCN temporary neurapraxia: 1 (0,6%)
Major complications (131 patients)	Meralgia paresthetica: 0 Dislocation: 1 (0,8%) (post-traumatic) Femoral shaft fracture: 1 (0,8%) (post-traumatic) Deep infection: 0 Aseptic loosening: 0 Revision for any reason: 0
Ossification (Brooker et al. [21]) (131 patients)	None: 91 (69.5%) I: 27 (20.6%) II (> 1 cm): 9 (6.9%) III (< 1 cm): 4 (3%) IV: 0
Oxford Hip Score [22]	45.2 (38–48; 2.6)
Harris Hip Score [23]	96.7 (76–100; 2.8)
UCLA score [24]	7 (5–10; 1.4)

LFCN: lateral femoral cutaneous nerve; UCLA: University of California, Los Angeles.

Future studies should assess the outcome of the ALDI compared to other approaches, and the rate of muscular involvement with this technique should be also analyzed.

The cup orientation is the key aspect of the arthroplasty survivorship and the possibility to view the usual orientation of the acetabulum and all the bone landmarks, guarantees high confidence for correct positioning. Hence, if the surgeon maintains the same visualization, he could adopt a new approach without difficulty. We have described in depth our technique because we think the ALDI could help surgeons to migrate easily from their traditional approaches to the anterior one.

Ethical review committee statement

This study has been approved by the local ethics committee and was conducted attending the requirements stipulated in the Declaration of Helsinki. All the patient gave their informed consent to participate in the study and to publish individual patient data (including images).

Disclosure of interest

The authors declare that they have no competing interest related to this paper. SC has interest unrelated to this work: he is an educational consultant for Zimmer–Biomet.

Table 4
Hot topics of the direct anterior approach.

Author	Subject	Approach	Cases	Results	Discussion
Lecoanet et al. [25]	Leg lenght discrepancy	DAA supine on standard table	56 THA	LLD over 10 mm: – 26,8% before the surgery – 21,4% post surgery	Negative effects only in 8,9% patients: all of them were without LLD before surgery and with lengthening post surgery.
Fessy et al. [26]	Dislocation	Posterior Anterolateral Lateral Anterior	– 428 stable THA – 128 unstable THA	Risk factors for instability: ASA, neurological disability, spinal disease, unrepaired joint capsule (mainly for posterior approach), cup inclination outside safe zone (30–50°)	The most important modifiable factors were cup positioning and capsule suturing. The approach type was not correlated to the dislocation rate.
Cogan et al. [27]	Dislocation in revision	DAA supine traction table	61 THA	6.6% of dislocations	Higher respect to primary, but acceptable for revision High BMI was an independent risk factor
Ozaki et al. [28]	LFCN impairment	DAA supine on standard table	122 THA	31.9% had symptoms	Hip function was not compromised. The only independent risk factor was short femoral offset, probably associated with longer surgical time, anatomical variations of LFCN, and greater force on retractors that provoked exaggerated tension to soft tissue and nerve.
Van Driessche et al. [29]	Postural effects	DAA supine posterolateral anterolateral	15 THA 14 THA 15 THA	DAA and anterolateral showed alteration of path length and center of pressure displacement speed	As a result of the deleterious stretching of hip muscles caused by surgical tools, anterolateral and anterior patients used more energy resources to maintain static balance than posterolateral
Bernard et al. [30]	Hip muscles electromyographic alterations	DAA	– 11 THA – 11 healthy subjects	Gluteus maximus, medius and TFL had higher activity bilaterally than controls	Greater energy expenditure to maintain static postural balance. Balance disorders were due to intraoperative stretching by retractors.

DAA: direct anterior approach; THA: total hip arthroplasty; LLD: leg length discrepancy; LFCN: lateral femoral cutaneous nerve; ASA: American Society of Anesthesiologists; BMI: body mass index; TFL: tensor fasciae latae.

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Authors' contributions

MF and SC obtained and analyzed the data, wrote and reviewed the manuscript.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.otsr.2019.02.026.

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