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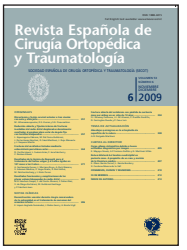

REVIEW ARTICLE

Surgical approaches to hip resurfacing surgery

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KEYWORDS
Approaches;
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Abstract
By preserving the femoral head, hip resurfacing arthroplasty is associated with a series of problems specifically related to the surgical approach that are not present in conventional hip replacement. These problems are attributable to the need to preserve blood supply and to allow a wider surgical exposure in order to place the different components appropriately. In this study, we analyze the blood supply to the femoral head and its relationship with the different approaches and surgical techniques used. We also review the different approaches used to perform hip resurfacing surgery, indicating the main advantages and disadvantages of each of them.

PALABRAS CLAVE
Abordajes;
Cirugía de la cadera;
Prótesis de superficie;
Prótesis de recubrimiento

Abordajes quirúrgicos en la artroplastia de superficie de la cadera

Resumen
La artroplastia de superficie de la cadera, al retener la cabeza femoral, presenta una serie de problemas con el abordaje quirúrgico que no tiene la artroplastia convencional. Estos problemas derivan de la necesidad de conservar la vascularización y de una exposición quirúrgica más amplia para colocar adecuadamente los componentes. Se analiza la vascularización de la cabeza del fémur y su relación con los diferentes abordajes y las técnicas quirúrgicas empleadas y también los principales abordajes empleados para realizarla, y se indican las principales ventajas e inconvenientes de cada vía.

Introduction

Hip resurfacing surgery is a kind of hip joint replacement surgery that preserves more bone in the proximal femur than conventional arthroplasty[1]. The fundamental difference between the two is that resurfacing surgery removes only a thin layer of the articular surface of the femoral head to subsequently resurface the portion that remains with a metal cap[1].

These differences with conventional hip replacement create three types of difficulties when performing hip

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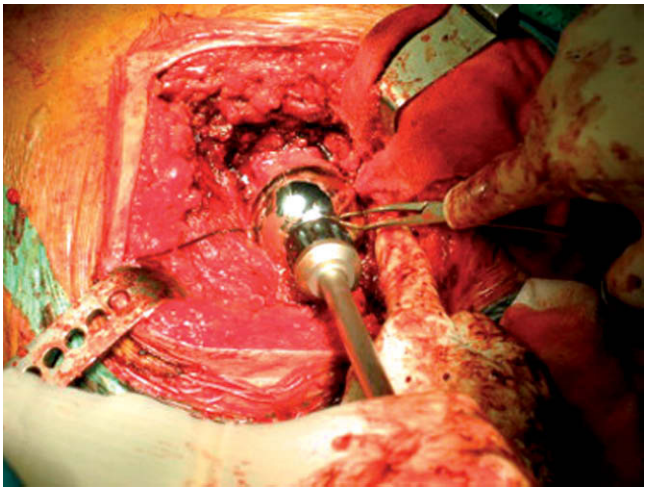

Figure 1 Hip resurfacing surgery. Note the large size of the femoral head.

resurfacing surgery. In the first place, in hip resurfacing arthroplasty, it is essential to preserve blood supply to the femoral head. It has been noted that some approaches may be more damaging than others for femoral head vascularization. Disturbing blood supply during the procedure could lead to higher rates of avascular necrosis and of femoral neck fracture, which is one of the most specific types of complication for this kind of prosthesis[2,3].

In the second place, preserving the femoral head means that the surgical technique is more difficult than that of conventional arthroplasty, where removal of the femoral head and neck greatly facilitates acetabular preparation.

Thirdly, similarly to conventional hip replacement, it has been shown that accurate component placement is of the essence to prevent complications[2]. One of the most important factors in achieving precise component placement is correct choice and performance of the surgical approach since complete circumferential vision of the femoral head and the acetabulum is needed to guarantee that components are implanted in the right place (fig. 1).

The purpose of this study is to present the available evidence on the different surgical approaches used to date for hip resurfacing surgery.

Blood supply to the femoral head

Given that the femoral head is not removed during resurfacing arthroplasty, it is of essence not to disturb its blood supply in the course of the surgical procedure[4]. One of the leading arguments used in the first generation of resurfacing prostheses to justify the failures sustained was that when the head is dislocated in the course of the procedure, an inevitable loss of the blood supply to the femoral head inevitably occurred, which subsequently led to femoral head necrosis[4]. Many authors have strongly resected these arguments on the basis of a number of precise anatomic studies on femoral head vascularization that are mentioned below:

In normal conditions, blood supply to the femoral head comes mainly from the medial femoral circumflex artery (MFCA)[4,5]. This artery originates in either the deep femoral artery (80% of the time) or in the common femoral artery (20% of the time)[4,5], if its origin is slightly more superior. The MFCA has 5 branches, one of which (the deep branch) is the one that vascularizes the femoral head. This branch runs posteriorly to the intertrochanteric crest between the pectineal muscle (medially) and the psoas tendon (laterally), along the inferior border of the external obturator muscle[5]. It subsequently continues its progression along the space between the quadratus femoris muscle and the lower gastrocnemius (fig. 2). At the proximal border of the quadratus femoris muscle, the trochanteric branch separates off and advances to the greater trochanter. The remainder of the artery continues its course and passes just above the (inferior and superior) gastrocnemius and internal obturator muscles. That is the point, just before reaching the insertion site of the piriformis, where it obliquely crosses the joint capsule separates into several terminal branches (from 2 to 4), which remain attached to the femoral neck until they penetrate the bone, from 2 to 4 mm before the bone-cartilage junction at the top of the femoral head (superior retinacular vessels)[5]. In 20%of cases some of the branches move towards the lower femoral neck (inferior retinacular vessels)[4,5]. It has been established that most of the vessels that penetrate the bone-cartilage junction of the femoral head are located in the superior area of the circumference[6]. If the circumference was a clock, the majority of vessels would be located at the 11 h position (above and slightly behind)[6].

For this reason, for the majority of hips, preservation of the insertion of the external obturator muscle and

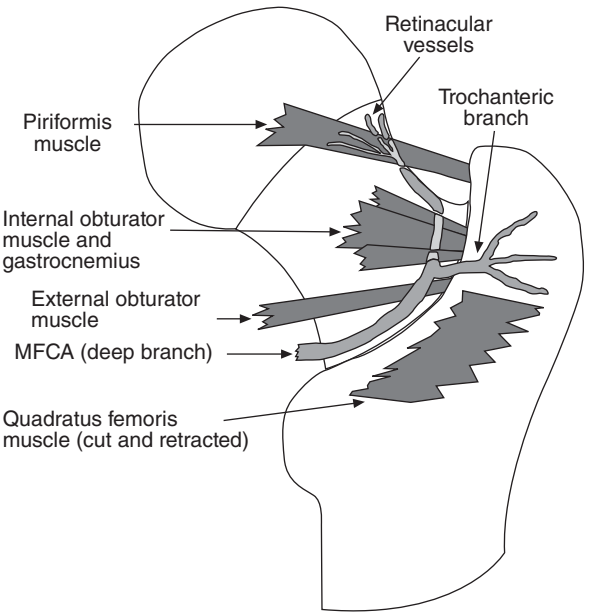

Figure 2 Course of the deep branch of the medial femoral circumflex artery (MFCA) in the posterior area of the hip joint. Note its relation with the external obturator muscle.

dislocation are basic to protect the artery from breaking or stretching[4] (fig. 2).

Anastomoses have been reported between the MFCA and the surrounding arteries. One of the most common ones is an anastomosis with the inferior gluteal artery along the piriformis muscle[4]. This could explain the persistence of some vascularization to the head in cases where the MFCA has been injured.

Apart from the MFCA, it is also essential to preserve the vessels that penetrate through the cartilage-bone junction (retinacular vessels). In this connection, it is important not to excessively clean the femoral neck, regardless of the surgical approach used. In 1953, Trueta[7], discusses the importance of retinacular vessels for intraosseous blood supply.

Notching the superolateral region of the femoral head on inserting the metal ball may also have its effects on vascularization[8]. As indicated above, the most important vessels for the femoral head (superior retinacular vessels) are located very closet o the superolateral area of the head-neck junction (fig. 3), which means that they could be injured by notching. In a study of 14 hips in patients subjected to conventional hip replacement through a Hardinge approach with preservation of the MFCA, Beaulé et al[8], before sectioning the head, made a simulation of a femoral notch and saw that blood supply to the femoral head decreased by up to 50% when the head was notched with respect to the pre-notching situation[8].

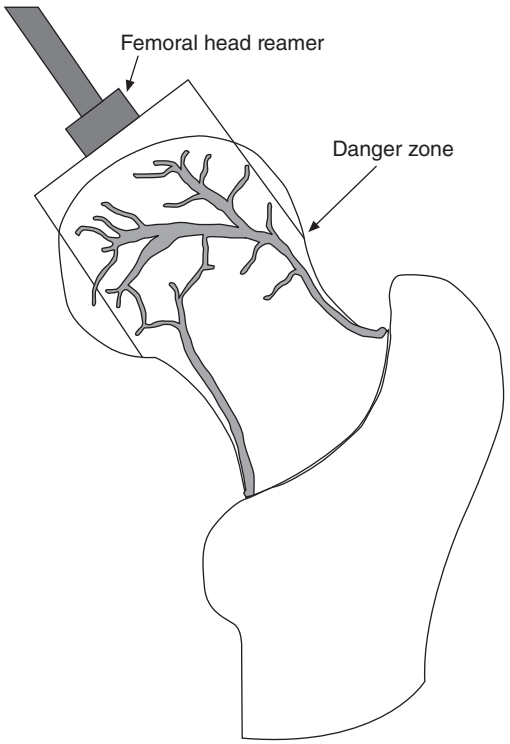

Figure 3 Intraosseous blood supply to the femoral head from the retinacular vessels. Note the proximity of the bone surface in the superolateral area of the neck, which may be injured should the neck get notched during prosthetic implantation

It has also been proposed that a decreased blood supply to the femoral head could be due mainly to an injury to the retinacular vessels caused by the (circumferentlal) head reaming technique; this would indicate that the type of approach selected may play a secondary role. Beaulé et al[9] measured the blood flow in the femoral head of patients implanted a resurfacing prosthesis before and after femoral read reaming. The Ganz approach[10] was used in all patients through a trochanteric osteotomy leaving the vastus lateralis in continuity, and an anterior capsulotomy, which in theory preserves the whole of the blood supply to the femoral head. The authors observed that in 9 out of 10 patients blood flow in the femoral head decreased by 70%[9]. They concluded that circumferential reaming causes an injury to the majority of the vessels that penetrate the cartilage-bone junction (retinacular vessels), these injuries being even more common than when an experimental notch was made in the superior region of the junction (70 vs. 50%)[8].

In order to try an minimize this damage to the retinacular vessels during femoral head reaming, 3 technical improvements have been proposed[9]: a) transferring the cylindrical burr to a more superolateral position (to prevent notches); b) staying as close as possible to the inferomedial area of the neck, and c) avoiding excessive valgus.

Bone viability may also be impaired by cement-induced thermal necrosis as well as by variable cement penetration (revisions of resurfaced femoral heads have shown that cement took up between 11 to 89% of the prosthetic cavity)[9].

In addition to the MFCA and the retinacular vessels, it has been argued that there could exist another source of blood supply to the femoral head in fractures with arthritiss[11]. In these types of fractures, the presence of circumferential osteophytes could induce the development of abundant intraosseous vascularization, which would lessen the significance of retinacular vessels[11]. This would explain the low rate of bone necrosis found histologically in revisions of resurfacing arthroplasties[12]. Nevertheless, this has not to date been fully ascertained[4,5].

Specific studies have been carried out of the final effect of the approach use don the blood supply to the femoral head. These studies directly measured intraosseous femoral head vascularisation following the procedure. Khan et al[11] performed 9 resurfacing arthroplasties through a direct lateral approach (without severing the MFCA) and 11 arthroplasties through a posterior approach (severing the deep branch of the MFCA) with a circumferential capsulotomy. They saw that blood supply to the femoral head decreased far more significantly with the posterior than with the direct lateral approach, although these measurement were made at the time of carrying out the femoral preparation (with the leg in a forced position). Steffen et al[13] specifically studied the effect of the typical position of the leg during the direct lateral approach on blood supply and observed that at maximum external rotation there was a sharp decrease in the blood flow to the femoral head, which bounced back with posture normalization[13]. This means that every approach leads to a transient reduction in the blood supply to the femoral

head during the procedure because of the leg's forced position; the reduction reverts when body posture normalizes. At any rate, blood supply to the femoral head is always more profuse with the direct lateral approach (MFCA is spared) than with the posterior approach (MFCA is severed)[11,14].

Main approaches used in resurfacing arthroplasty

Three types of approach have been described for conventional hip replacement: anterior, anterolateral and posterior, with several variants within each[15]. All of them have been used more or less successfully for hip resurfacing arthroplasty.

Other approaches than the conventional ones have also been described, such as the medial approach[16]. In 1908, Ludloff described the medial approach for reduction of congenital hip dislocation[15,17]. Thomas published a variation of this technique to allow placement of conventional hip prostheses, which he has used since 2002. To date no results have been published by other groups that attest to its validity. Furthermore, that approach has not as yet been used to implant hip resurfacing prostheses[15].

Anterior approaches

Over 100 years ago, Smith-Petersen[15,17] popularized the anterior approach. The approach is performed between the sartorius muscle (innervated by the femoral nerve) and the tensor fascia latae muscle (innervated by the superior gluteal nerve)[17]. One of the main risks inherent in this approach is damaging the lateral femoral cutaneous nerve, which provides sensory information to the superolateral region of the thigh and runs towards the skin between the 2 muscles through which the approach is conducted (the sartorius and the tensor fascia latae). If the nerve is severed, sensibility to the area is lost and a very painful neuroma may ensue[17]. To prevent it, a more lateral skin incision has been proposed[18]. Recently, minimally invasive variants of this approach have been described, i.e. with skin incisions of less than 10 cm[18].

When a hip resurfacing prosthesis is implanted through this approach, the main problem lies in correct visualization of the acetabulum. Since the head is preserved in these prostheses, it is often necessary to widen the approach by partial cuts into the tensor fascia latae or gluteal muscles[15], which increases the risk to damage the lateral femoral cutaneous nerve. In addition, this approach is unfamiliar to most surgeons[2]. It may be necessary to use a special table or a leg holder to support the leg as it falls further to hip dislocation; these should be in place before the procedure commences[2].

The main advantage of this approach is preservation of the blood supply to the femoral head[2], since no damage is inflicted on the MFCA, which is the main source of vascularization to the head. Moreover, it preserves the patient's abductor muscles (important for early motion). Another advantage is patient placement in the supine position (for anesthetic management).

Anterolateral approaches

The anterolateral approach is one of the most common approaches used for implantation of total hip replacements[17]. It was popularized by Watson-Jones[15] and subsequently modified by different orthopedists (Charnley, Harris, Müller, etc.)[17]. All of these approaches are performed through the same anatomic interval: between the tensor fascia latae and the gluteus medius. In all its variants, the approach involves a detachment of some or all of the hip abductor musculature in order to appropriately adduct the femur and allow good access to the acetabulum[17].

There are some variations to this approach such as trochanteric osteotomy, the Ganz approach, the Hardinge direct lateral approach and the Bauer transgluteal approach.

Conventional trochanteric osteotomy affords excellent visualization of the joint[2]. If care is taken to carry out this osteotomy extracapsularly (without cutting into the capsule), blood supply to the femoral head can be adequately preserved. Nonetheless, such problems as pseudoarthrosis and hardware breakage have been reported in connection with trochanter reattachment, which has lead to the virtual abandonment of this approach.

In 1992, Ganz et al developed a technique that combined la trochanteric osteotomy (in continuity with the vastus lateralis) with a Z-shaped anterior capsulotomy to preserve as much of the vascularisation of the femoral head as possible[10]. This technique was originally indicated to dislocate the femoral head without disturbing its vascularization thereby being able to treat joint conditions that did not require the use of a prosthesis (such as femoroacetabular impingement). The technique has recently been applied to resurfacing prostheses as it allows preservation of the blood supply to the femoral head as well as an excellent exposure. In a recent series of 50 hip resurfacing prostheses, this technique has afforded satisfactory short-term (one year) results, with no approach-related complication[19]. In order to apply the technique to resurfacing hip surgery previous experience with the approach is required.

The direct lateral or transgluteal approach (popularized by Hardinge) is a modification of the anterolateral approach inasmuch as it is carried out through the fibers of the gluteus medius and maintains the continuity between the anterior region of the gluteus medius and the vastus lateralis[17]. It has the advantage that it does not cause serious injuries to the hip abductors, which makes it one of the most widely used anterolateral approaches at present. However, it entails the risk of injuring the superior gluteal nerve (it innervates the abductors muscles), which runs between the gluteus medius and the gluteus minimus, approximately 3 to 5 cm over the upper edge of the trochanter. Care must be taken not to extend dissection of the gluteus medius beyond this area. The clinical repercussion of the potential injury to the superior gluteal nerve has been subjected to debate. In a study on 81 patients, Ramesh[20] found 19 patients (23%) con Trendelenburg gait following a direct lateral approach carried out to address an injury to the superior gluteal nerve. Eight of them recovered partially, which means

that 11%of patients were left with permanent neurologic damage. Recoveries were considered to be due to the use of retractors that could compress the superior gluteal nerve. Nevertheless, in a recent study of 40 patients[21] permanent neurologic damage and Trendelenburg gait were found in only one patient. All of these studies were conducted in patients subjected to conventional hip arthroplasty. There are no analogous studies on resurfacing arthroplasties, but taking into account that resurfacing implants are larger, the risk of neurologic injury could be higher than in conventional arthroplasties.

Posterior approach

The posterior approach is the most common approach used at present in the United States, and it is the approach to hip resurfacing arthroplasty currently recommended by the designers of the first models of the present generation of hip resurfacing prostheses[22]. The approach is carried out through the gluteus maximus and behind the gluteus medius muscle, so as not to disturb the abductor system[17]. The performance of this approach by means of a "minimally invasive" technique has recently been reported. In actual fact the approach ought to be called a "short incision" one[18], except that the skin incision is shorter than 10 cm.

The advantage of this approach is the excellent exposure it offers to the femoral head, which is normally more difficult to prepare, without causing any damage to the extensor system (which permits an earlier recovery)[2]. Potential problems include the risk of disturbing blood supply (the deep branch of the MFCA is severed) and sectioning the short rotators[2], as well as poorer visualization of the acetabulum if exposure is not appropriate.

Several technical considerations must be borne in mind when performing resurfacing arthroplasty through a posterior approach. Firstly, one of the commonest errors is an incorrect incision into the gluteus maximus muscle. It is key to locate the junction between the posterior third of the femur the line that dissects the neck. At this point, the muscle must be retracted proximally, sectioning only the fascia that covers the muscle and detaching (not sectioning) the gluteus maximus fibers. Incorrect identification of this point can be problematic. If it is posteroinferior, it will be difficult to place the anterior retractors; if it is anterosuperior, it will be difficult to place the posterior retractors. If the latter case, the surgeon may cut off the insertion point of the gluteus maximus into the fascia to improve his approach.

It has been shown that the short rotators and the joint capsule must be repaired in all cases (fig. 4). Different studies concluded that in conventional hip arthroplasty prosthetic dislocation rates when the capsule and the short rotators were repaired were close to 0%.while the figure rose to if the aforementioned structures were not repaired[23,24]. A meta-analysis of dislocation rates following conventional total hip replacement has shown that prosthetic dislocation rates with the anterolateral, the (Hardinge) direct lateral and posterior (with capsule and rotator repair) approaches is similar (0.70; 0.43 and 1.01%, respectively)[25]. There are no data for resurfacing arthroplasties, but the figures are probably similar.

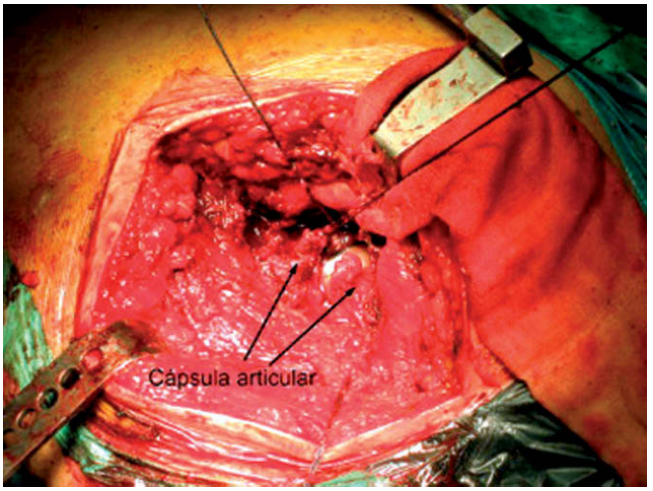

Figure 4 Joint capsule repair following hip resurfacing surgery through a posterior approach.

"Minimally invasive" approaches

"Minimally invasive," or rather "short incision" approaches have been developed in an attempt to reduce soft tissue damage and thereby facilitate postoperative recovery.

A "standard" incision in conventional hip arthroplasty is considered to ranhe between 16 and 61 cm. Therefore, the term "short incision surgery" would include any surgery where the incision is shorter than 15 cm. However, this concept varies widely depending on the author, the type of approach used and the patient's weight[18].

Currently, there are 3 common minimally invasive approaches: the posterolateral approach (the most common one), the (Hardinge) direct lateral approach and the anterior approachr[18]. All "minimally invasive" approaches are carried out in practically the same way as the conventional approach, but decreasing the length of the skin incision by using specialized instruments. The 2-incision "minimally invasive" approach described by Vail and Callaghan[18] and Berger[26], in use since 2001, is a variant of the Watson-Jones' anterolateral approach and requires the use of radioscopy for the insertion of a conventional prostheses. This approach is beset with difficulties and many early complications have been reported[18,27], which explains why it has fallen into disuse.

The usefulness of these approaches is the subject of much controversy. They do contribute some advantages such as decreased blood loss, shorter hospital stay and better short-term clinical results without lengthening OR time, altering the position of the implants or increasing perioperative morbidity. Nevertheless, they also have some disadvantages such as greater difficulties in terms of component placement. In general, results are similar to those obtained with conventional approaches[18,28]. It is true that the cosmetic result is better, which is probably the reason why surgeons are now making their conventional incisions shorter than in the past. In any case it must be remembered that since accurate component placement is the most important consideration, the surgeon must be prepared to extend his incision if necessary[18,28].

In this context, when preparing the acetabulum it is important to remember that the femoral head is retained in hip resurfacing arthroplasty, for which reason even if it is indeed possible to carry out the surgery with a minimal incision, the latter may have to be somewhat longer than in conventional hip replacement. Both the technical difficulties and the learning curve will be larger.

As regards resurfacing prostheses, there is a paucity of studies comparing the results of "minimally invasive" surgery with those of conventional surgery. Mont et al[29] compared the results of the (Hardinge) direct lateral approach performed in a group of 25 patients with an incision shorter than 15 cm ("minimally invasive" group) with those of a 25 patient group where a 16-cm conventional incision greater than 16 cm was used by the same surgeon. The authors found less intraoperative blood loss (566 ml vs. 683 ml) and better short-term results on the Harris' scale in the short incision group. Nonetheless, long-term results were similar as was the position of the implants. The conclusion of these authors was that a short incision is also an option for hip resurfacing surgery[29]. With respect to a "minimally invasive" posterior approach, only a paper by McMinn et al[30] has been published, which is a retrospective series of 232 patients operated with a 11.8-cm incision. The results of this series indicate that OR time and component placement are similar, but immediate pain is less intense, hospital stay is shorter and recovery is faster. The authors indicate that the technique has a significant learning curve, since in a previous series of 114 prostheses there had been 2 failures due to poor component positioning[30].

In summary, in resurfacing arthroplasty the best alternative is probably to reduce the length of incisions in a gradual way until a reasonable limit is reached. However, the surgeon must always be prepared to extend the size of the incision if necessary.

Choosing the right surgical approach

The debate as to which is the best approach to hip replacement is far from over. A very important consideration when deciding on the right approach is the surgeon's training and previous experience. All surgical approaches are associated with a learning curve that must be overcome. A surgeon with experience of a certain approach will in all likelihood be more successful with that approach than with any other one. Furthermore, component orientation varies depending on the approach selected, which may lead to (involuntary) errors if a surgeon keeps changing between approaches (especially between the anterior and the posterior approach). Another important factor is instrumentation: Designers of a certain kind of prosthesis may prefer a specific approach, which means that the instruments in that prosthetic system will probably work best with that specific approach[15].

There are very few studies that compare the different surgical approaches. McBryde et al[22] from Birmingham, carried out an interesting retrospective study comparing the posterior and the (Hardinge) direct lateral approaches. They used 774 resurfacing prostheses implanted through a posterior approach by a single surgeon and 135 implanted through a direct lateral approach by another surgeon. Both groups were homogeneous in terms of age and gender. No difference was found at 5 years' follow-up (range: 2-10 years) between both groups as regards complications, need of a new surgery, clinical surgical results and implant survivorship (97.9 vs. 97.2% at 8 years). The authors stated that, even if the posterior approach could be considered more damaging to the vascularization of the femoral head, this effect is not significant, either because it is transient, caused by intraosseous circulation in osteoarthritic patients or because the same vascular injury is caused when the femoral reamer is used in the direct lateral approach. The conclusion of this study is that designers of the current generations of resurfacing prostheses still recommend the posterior approach, although the direct lateral approach can be equally effective if performed by surgeons experienced in that approach.

Another study[31] looked at the technical difficulty inherent in each of the 2 approaches (posterior and direct lateral) by analyzing component placement accuracy with both approaches. In the study, one same surgeon carried out 41 resurfacing arthroplasties through a posterior approach and 23 through a direct lateral approach. The authors found no

Table 1 Pros and cons of the most usual approaches used for hip resurfacing surgery

Approach	Quality of exposure	Blood flow to the head	Risks and dangers
Posterior	Excellent	Disturbed	Retractor-caused transient femoral nerve palsy
Direct lateral (Hardinge)	Very good	Preserved	Abductor weakness
Conventional transtrochanteric	Excellent	Preserved if the osteotomy is extracapsular	Trochanteric pseudoarthrosis and migration/ breakage/ loosening of hardware
Ganz (digastric trochanteric)	Excellent	Preserved	Abductor weakness and risk of pseudoarthrosis. Loosening of fixation screws
Anterior	Good	Preserved	Visualization of the cup may be difficult. This is an unfamiliar approach, seldom used in conventional surgery.

Shimmin A, Beaulé PE, Campbell P. Metal on metal hip resurfacing arthroplasty. J Bone Joint Surg Am. 2008;90:637–54.

differences in terms of femoral component orientation between both groups. However, acetabular component orientation was more horizontal (37.5°) with the posterior approach than with the direct lateral approach (43°). As the orientation achieved in the posterior approach was the more physiological of the two, the designers of the Birmingham Hip Resurfacing System still recommend the posterior approach.

In a nutshell, the data available at present is insufficient to recommend one surgical approach over another. All of them have their pros and cons (table 1). Currently, the most frequently used approaches –and those surgeons have most experience of – are the Hardinge direct lateral approach and the posterior approach. When choosing between these 2 approaches, the surgeon should probably use the one he is more experienced with.

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