

Dual mobility cups for total hip arthroplasty: tips and tricks

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Abstract – Since its creation in 1974, the Dual Mobility Cup (DMC) has been gaining in popularity, especially in the past decade. This intensive use could lead to inappropriate use and consequently to an increased complication rate. Compliance with conceptual requirements and surgical techniques will prevent the occurrence of complications that can be wrongly attributed to implants. In this context, we feel that it is essential to share our tips and tricks as well as an overview and an explanation of common errors, based on more than 45 years of clinical and research experience. From basic principles, including indications, implant choice and implant compatibility, to surgical tips, in this article orthopedic surgeons will find a practical overview of DMC in order to use it safely and with confidence.

Key words: Total hip arthroplasty, Dual mobility cup, Surgical technique, Tips, Tricks.

Introduction

Total Hip Arthroplasty (THA) is one of the most successful procedures in orthopedic surgery. Among various cup types, liner and head combinations that exist, the Dual Mobility Cup (DMC) was invented in 1974 by Gilles Bousquet in Saint-Étienne [1, 2]. The DMC concept combines Charnley’s low-friction arthroplasty principle [3], in which a small-diameter head articulates with an ultra-high molecular weight polyethylene (UHMWPE) liner, and the McKee-Farrar principle [4], in which a head with similar dimensions to the native femoral head articulates with a cup to increase the stability of the prosthetic joint. This combination is possible because the DMC liner maintains mobility within the metal cup. The three primary goals and advantages of the DMC concept are to increase implant stability, restore nearly physiological hip joint range of motion and to reduce wear [1, 2].

Disparaged for a long time, the DMC concept is in full expansion. This concept has evolved since 1974 with several modifications that have reduced the complication rate, improved implant survival, and expanded its indications [5]. Due to good clinical outcomes and survival rate, indications are becoming broader and are no longer limited to revision surgery. This has allowed the DMC concept to spread beyond France and to

become international. Several recent publications reflect the surgical community’s growing interest in this implant [6, 7].

The intensification of the use could lead to inappropriate use and consequently to an increased complication rate. Compliance with conceptual requirements and surgical techniques will prevent the occurrence of complications that can be wrongly attributed to implants. In this context, we felt obliged to share our tips and tricks, based on more than 45 years of clinical and research experience [8–10].

This aim of this paper is therefore to provide an overview of technical and theoretical requirements necessary to achieve a successful DMC implantation. Through tips and tricks, we will present a detailed overview of the use of DMC, including indications, choice, and compatibility of DMC implants, surgical techniques, and management of complications.

Indications and DMC implants choice

Since the beginning, Gilles Bousquet recommended DMC to all his patients requiring THA, without an age threshold: primary and secondary osteoarthritis, femoral neck fracture, aseptic osteo-necrosis, arthritis sequelae, hip dysplasia, congenital dislocation. DMC were also offered for revision surgery, either for recurrent dislocation or for loosening.

However, out of Saint-Étienne and Lyon, these implants were usually used for revision procedures or in patients with

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Table 1. Issues and their solutions regarding implant choice.

Issues	Solutions
Insufficient bone quality or non-hemispheric acetabulum	Tripod DMC or even a DMC with a hook
Significant acetabular defect	Reinforcement cage + cemented DMC
Extensive bony acetabular defect	Custom reinforcement cage + cemented DMC
Stick to the patient anatomy in complex revision	<ul style="list-style-type: none"> • Inner diameter of the reinforcement cage = outer diameter of the initial cup. • Cemented DMC diameter = initial cup diameter – 4 to 6 mm (thickness of cement).

a high dislocation risk. Since that time, due to encouraging results of both stability and longevity, the age limit for DMC was reduced, and the indications were expanded and are no longer limited to revision surgery only [6].

Prerequisites

On one side, DMC advantages are the decreased dislocation risk and restoration of a full hip joint amplitude [5]. Consequently, the first indication widely recommended for using DMC is for patients that are at a risk of dislocation. This risk depends on the etiology, which is higher in revision surgery, in post-traumatic arthritis or in cases of pathoanatomic changes (dysplasia, congenital luxation, and arthrodesis). It also depends on other patient characteristics (neuromuscular deficits, risk of falling) and activity level. Following primary THA, the dislocation rate with DMC is between 0% and 2% regardless of the DMC generation being used [1, 4, 8, 10–20]. The second primary indication for DMC is a patient requiring a restoration of a high range of motion.

On the other side, the main drawback of DMC is wear of the polyethylene liner [21]. For this reason, the ceramic-ceramic bearing couple is the gold standard in active patients. However, even in these young patients, which represent the worst scenario for wear, results with DMC at more than 20 years of follow-up were comparable to those of MoP bearing studies [22]. At 22 years' follow-up, the survival rate of the DMC was 77% in patients under 50 years of age (mean age of 41 years [9]). The revisions were performed because of liner wear with 15% aseptic loosening and 10% intra prosthetic dislocation (IPD) when the wear affected the retaining ring. The collection of improvements made to this first generation of implants (new coating, better press-fit fixation, change in the liner design and density, and improved clearance between the liner and cup) have reduced the stress at the interface and thus improved implant survival [5]. Long-term survival of first-generation implants, which was already comparable to other bearings, is now close to 100% in the medium term. These promising results must be confirmed by long-term studies.

In any case, the philosophy inherent in the concept of DMC tends toward the restitution of an ideal anatomy, both in terms of dimensions (cup diameter) and positioning (center of rotation). This implies limiting the widening of the cup diameter (jumbo cup type) as far as possible and compromises moving the center of rotation, in order to avoid impingement or premature wear. In revision surgery, it is advisable to keep the dimensions of

the revised cup as large as possible for the new revision cup. Bone defects will be filled by bone grafting (allograft, autograft, substitute) or trabecular metal. Our current practice matches Gilles Bousquet's preference for grafting, allowing for reconstitution of the bone stock around the implants, allowing the chosen metal framework to be fixed at a distance from the revision zone to allow for a good reconstruction.

DMC in the setting of primary surgery

Press-fit only implants allow adaptation to normal anatomy with adequate bone quality. In this condition, macrostructures and combined titanium and hydroxyapatite coating ensure good primary and secondary fixation (Table 1) [8].

In the case of dysplasia or congenital dislocation, we recommend the use of an implant with additional fixation properties. Our preference is to use tripod implants that reinforce press-fit fixation in all three planes. Small diameter tripod implants should be used in these indications to preserve bone stock and maximize bone coverage around the implant. These implants can also be used to secure an acetabular bone graft. Although they are larger and require more exposure time, tripod implants with obturator hooks and screwed flanges are also an option in these types of cases.

DMC in the setting of revision surgery

Once the initial implant has been removed and the periacetabular area is exposed, the evaluation of bone defects allows for orientation toward the type of implant required. Usually, we used the Paprosky classification for planning further steps (Figure 1).

If there are no defects (Paprosky 1A) and the bone quality is good, the press-fit only implant is possible. However, we advise to maximize the primary fixation by a tripod implant if the slightest doubt occurs. This is an almost systematic attitude in our experience, as this implant does not require any additional bone preparation and the time necessary for the positioning of the pegs and the screw is minimal with regard to the outcome achieved.

For 2A stage, the use of a tripod cup is always recommended [23]. For lesions 2B (walls) or 2C (back), the implant with obturator hook and screwed flanges allows a third additional means of fixation to be added, while maintaining the press-fit and tripod fixation [24]. The addition of graft (or trabecular metal) is thus facilitated.

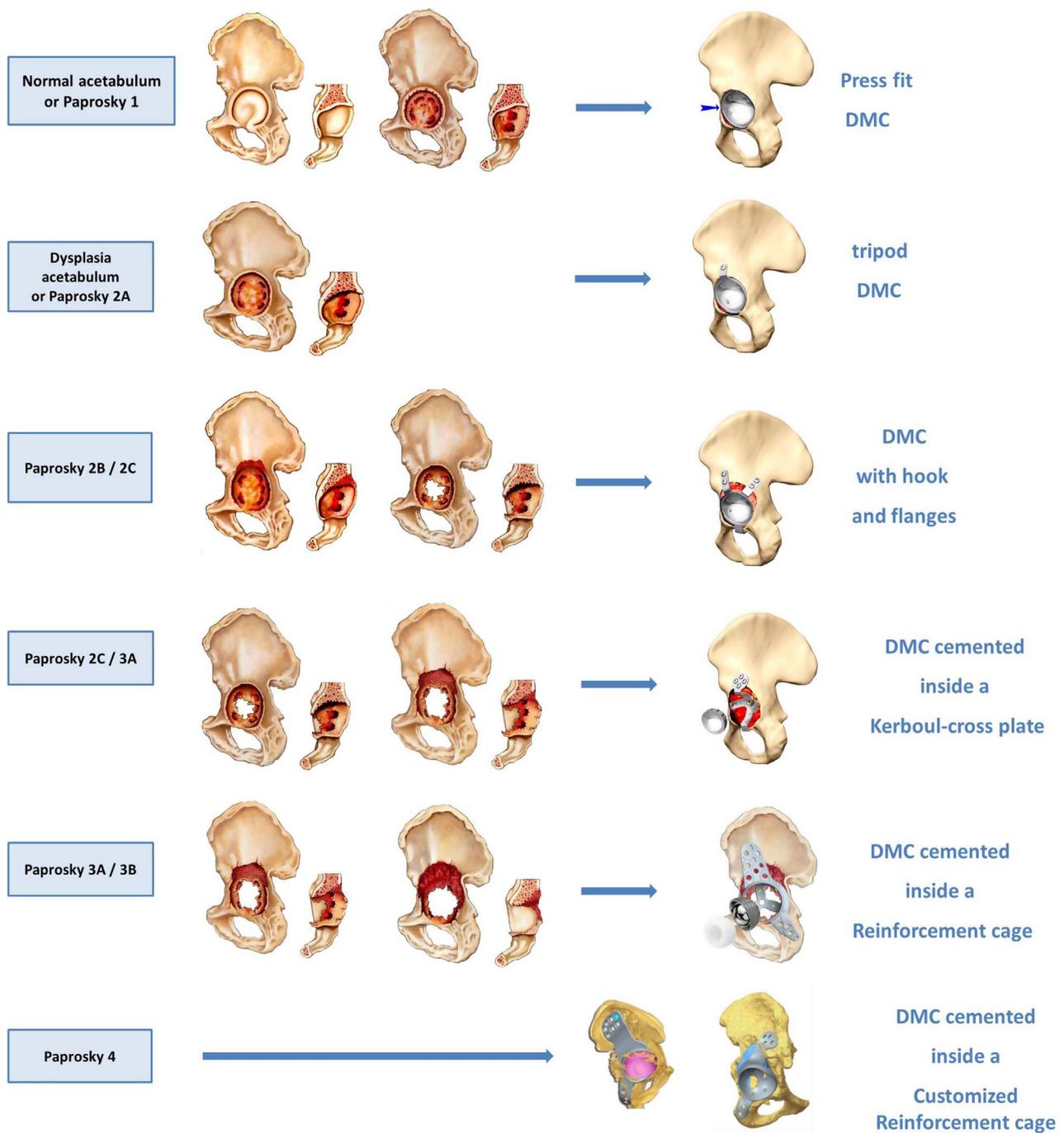


Figure 1. DMC choice regarding Paprosky classification (reprinted with SERF[®] permission).

For more extensive 2C and 3A stages, the addition of a metal reinforcement allows fixation in healthy bone. We use a Kerboul cross-plate. A special DMC is cemented into this. Its dimensions should be close to the cup initially planned, and it is these dimensions that guide the choice of the external diameter of the cross-plate and not the other way round [25–27]. However, surgeons have to keep in mind the thickness of the cement required to fix the DMC. A minimum cement thickness must be respected, to avoid galvanic coupling (cup-structure contact) but also to maximize cup fixation. Two-to-three-mm cement

thickness seems sufficient, resulting in a cemented cup diameter of 4 or 6 mm less. We recommend ideally matching the internal diameter of the cross-plate to be chosen with the external diameter of the initial implant, as this seems to be a good compromise between bone reconstruction, mobility and stability.

However, the Kerboul cross-plate is not sufficient for internal fixation in stages 3B and 3C, in which case a Burch-Schneider-type reinforcement cage can be used [27].

For stage IV, pelvic discontinuity in most cases requires a custom-made tri-flange reinforcement cage, allowing farther

Table 2. Tips and tricks for implant compatibility

Cup	The cup should be specifically designed for a dual mobility system.
Liner	The liner used must be from the same manufacturer as the cup. The liner and cup are an inseparable combination. The size of the liner must be in accordance with the size of the cup; according to the manufacturer's recommendations. UHMWPE or XLPE liners may be used. Please note that no long-term studies are available on the evaluation of the XLPE in DMC.
Femoral head	Heads with a diameter of 22 mm are to be favored. 28 mm diameter heads should not be used with cups smaller than 54 mm.
Femoral stem	The femoral stem used should have a thin polished neck that is trapezoid, elliptical or circular in shape.

fixation while respecting the patient's anatomy. The surgeon will choose whether he prefers to fill the loss of substance with metal, if possible trabecular, or allograft (massive or, at our preference, fragmented).

Implant compatibility for DMC

Like for any orthopedic implant, the use of MDC requires guidelines. There are rules that should be followed in order to avoid complications. In general, implants designed specifically for DMC should always be favored. Schematically, the DMC system is composed of a cup, a mobile liner, and a femoral head impacted on the femoral stem (Table 2).

Cup

The shape is usually cylindrical-spherical. This shape increases the jump distance and thus reduces the risk of dislocation. Most DMCs are symmetrical. The DMC was created with a cementless fixation rationale in mind. However, cemented models do exist, most often in combination with a metal reinforcement cage. DMC cemented into the native acetabulum remains possible. The DMC cups available are either made of Cobalt-Chrome-Molybdenum (CoCrMo) or 316L stainless steel.

Cup-liner

The first rule is to use the correct liner for the cup being used, from the same manufacturer, designed specifically to be used with the cup. The liner and the cup are inseparable, in order to respect the clearance between the cup and the liner. Schematically, the liner has an external diameter slightly smaller than the internal diameter of the cup. This difference, or clearance, is already calculated by the manufacturer. It is absolutely necessary not to use a larger liner (risk of blockage) or a smaller liner (risk of early wear). The clearances have been altered to avoid jamming of the inner and outer surfaces of the liner.

Liner density

Since the first PEs, the liners are now denser (UHMWPE), reducing wear complications. The classical PE is UHMWPE. DM liners made of cross-linked polyethylene (XLPE) have been recently introduced. The benefits of this latest modification are still being debated. These new liners raise the crucial

question of behavior at the retention collar at the time of impaction (femoral head into the liner). This leads to many questions that remain unresolved to this day: risk of microfractures, adaptation of the design of the collars to XLPE, etc. [28, 29]

Liner-femoral head

The DMC system has been designed to be used with 22 mm heads in order to respect the logic of Charnley's theory (smaller diameter, less wear). However, 28-mm heads can nowadays be used, provided they are used in large liners to avoid insufficient PE thickness in the liner. In order to guarantee a circumferential thickness of at least 10 mm PE, we recommend using 28-mm diameter heads only for liner sizes larger than 54 mm.

The design of the liners has changed considerably since the introduction of the first DMC. The chamfer and retention mechanisms were redesigned to reduce wear in the retaining ring. This resulted in a significant reduction in the occurrence of intraprostatic dislocation (IPD) [2, 28, 30].

Femoral head

The composition of the heads can be either 316L stainless steel, CrCo, or ceramic. Skirted head systems are not recommended. These systems, by increasing the diameter of the neck, will promote contact between the femoral neck and the retention system of the liner and can lead to an IPD.

Femoral stem

The first generations of DMC were associated with femoral stems with wide, rough necks. With a contact between the neck and ring, this combination led to the occurrence of a specific complication of DMC: the IPD [2, 28, 30]. Since the change to a thin polished neck that is trapezoid, elliptical, or circular in shape, no IPD has been reported. In summary, combination DMC and liner are inseparable and must be issued by the same manufacturer. The liner and femoral stem combination may be from a different manufacturer, but the stem must have a neck compatible with the DMC system.

Intra operative tips and tricks

Pre-operative planning

Like a classic THA, DMC is not made to compensate for deficiencies in planning. The basic principles of hip arthroplasty

Table 3. Tips and tricks for posterior approach.

Soft tissue management	<ul style="list-style-type: none"> • We encourage a minimally-invasive approach with preservation of piriformis tendon. • No specific recommendations for closing and reconstructing of the joint capsule and external rotator muscles. • Keep the transverse acetabular ligament intact to determine the acetabulum version.
Acetabulum preparation	<ul style="list-style-type: none"> • Requires a good acetabular exposure. • Start by reaming vertically with a small diameter reamer in order to remove all the osteophytes around the acetabular fossae. • The inferior edge of the reamer is then placed in line with the transverse acetabular ligament to respect anatomic anteversion. • Try to use smallest cup size that will allow a good primary fixation.
Cup positioning	<ul style="list-style-type: none"> • Keep a sufficient anteversion to avoid psoas impingement and decrease the risk of dislocation. • A supero-posterior bone coverage defect of the cup is often observed and has no consequences.
Intraoperative testing	<ul style="list-style-type: none"> • For stability tests, the hip is flexed at 90° and an internal rotation is gradually applied. If dislocation occurs at more than 45°, the THA is considered stable. • For length and femoral offset parameters, the piston sign observed with knee fully extended has to disappear when the knee is flexed at 90° of flexion.

must be respected. Restoration of the patient anatomy remains the key to success for good clinical outcomes and to avoid complications. Among them, restoration of the hip center and the femoral offset, as well as the position of the femoral osteotomy in primary surgery are crucial points on which planning should be based.

Posterior approach

Historically, DMC has been developed for the posterior approach. In Saint-Étienne department, all patients were operated using a postero-lateral approach, developed initially by Moore. Although the posterior approach is associated with a higher dislocation rate, the use of DMC has resulted in dislocation rates comparable to implants placed through a direct anterior approach. In large studies with more than 20 years' follow-up conducted in our department, no dislocations occurred in spite of exclusive use of the posterior approach [10, 11]. The main advantage is the ease of access and excellent exposure, which allows good positioning of the implants which is necessary to minimize complications. Disadvantages are the risk of damage to the sciatic nerve, which is extremely rare, and a slower recovery time due to the surgical dissection of external rotators of the hip.

Some tips and tricks can facilitate exposure, bony preparation, implant positioning, and intra-operative testing (Table 3).

Soft tissue management

The first question often asked is: "Should the tendon of the piriformis muscle be dissected or preserved? This question is related the approach itself rather than the use of DMC. Following the trend of minimally invasive surgery, we keep it intact in primary surgery. Specific instruments have been developed for that, allowing for a reduction of both the size of the scar and the soft tissue damage. These include curved retractors and reamers.

The second question is: "Is it necessary to reconstruct the joint capsule, as well as the external rotators when using a DMC?". Some surgeons advocate that it increases external rotation force and reduces the dislocation rate. Others, including

Gilles Bousquet, leave the joint open and suture only the fascial layer and the gluteus maximus aponeurosis. To our knowledge, the literature does not answer this question. It depends mainly on the surgical training habits.

Acetabulum preparation

For this step, the fundamental prerequisite is a good exposure of the acetabulum. An anterior retractor is placed on the anterior horn after removal of the acetabular labrum. In order to expose the posterior part, we use a "capsule self-retainer" taking out the capsule, close to the posterior horn (Figure 2).

Especially in severe osteoarthritis, we start the reaming around the acetabular fossa. It allows for restoration of the anatomic hip center and prevents proximal reaming. For this step, we use a small reamer and start reaming vertically, or perpendicular to the horizontal axis.

After this first step, we ream directly into the anatomic position. We keep the transverse acetabular ligament intact to determine the anatomic anteversion of the acetabulum. The inferior edge of the reamer is placed in line with this ligament.

As previously explained, we try to use press fit DMC as much as possible. The fundamental principle of this is to use the smallest cup size possible that at the same time allows a good primary fixation. Usually, for primary osteoarthritis we try to use a cup size that is similar to the femoral head diameter, or slightly larger (e.g 45-mm or 47-mm DMC for femoral head of 45 mm). For neck of femur fractures, with lower bone density, the targeted size is one or two mm bigger than the femoral head diameter. If the primary stability is not achieved with the trial cup of the proposed size, we prefer to use a tripod cup in order to avoid impingement risk which exists with big cup sizes.

Cup positioning

Sufficient anteversion is required to avoid psoas impingement and to increase hip stability (Figure 2). The anatomical landmarks used are: the transverse acetabular ligament to control acetabular depth, height and version, anterior and posterior horns as secondary guides for the version and the

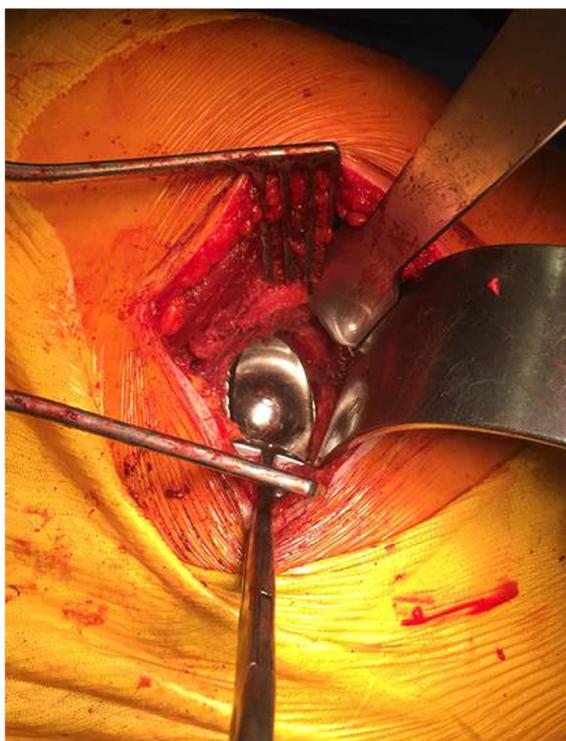


Figure 2. Posterior approach: exposure and cup positioning. One anterior Hohmann retractor is positioned in the anterior horn and a self-retainer, taking out the capsule, is placed close to the posterior horn. The cup is positioning in line to the transverse acetabular ligament to restore the anatomic anteversion.

acetabular roof for controlling of the inclination. In some cases, even in good cup positioning, there is a bone defect in the superior-posterior aspect of the acetabulum. This has no consequence and should not lead to a change in cup positioning.

Intraoperative testing

With femoral and cup trial implants, we perform dynamic tests in order to test the stability of the hip, to rule out any risk of impingement and to verify the good restoration of hip center.

For stability tests, the hip is flexed at 90° and an internal rotation is gradually applied. If dislocation occurs at more than 45°, the THA is considered stable.

For length and femoral offset parameters, our main test is based on the evaluation of soft tissue tension. First, with the hip and knee in extension (hamstrings stiffened), traction is applied in the axis of the limb (Figure 3a). The test is considered good if there is a movement, such as a piston in a cylinder, between the head, the liner and the cup. Then the same test is repeated with the knee bent at 90° (hamstrings relaxed). This piston effect should disappear (Figure 3b).

Anterior approach

The direct anterior approach (DAA) is considered to have a lower dislocation rate due to muscle and posterior capsule preservation [31]. Soriali has described a revision rate for

instability of 0.11% on 1764 THA by DAA [32]. However, since the development of the minimally invasive posterior approach (MPA), the differences in terms of stability are less obvious; however, complications remain possible [33]. Some indications of DMC via DAA can be interesting. Few studies have reported the results of a dual mobility cup (DMC) via DAA, which combines a technically demanding approach with a cylindrical-spherical cup [34]. The risk of complications is similar to the other approaches. Some tips and tricks can help avoid main difficulties (Table 4).

Soft tissue management

DAA is performed according to the “Hueter Gaine” anterior approach [35], in supine position with a standard orthopedic table or with a traction table. The approach is typical until the acetabulum is reached. Some tips can facilitate the acetabular exposure and preparation. We recommend a capsulectomy. To improve the acetabular exposure, the reflected head of rectus femoris can be released at the superolateral part of the acetabulum. Two Hohmann retractors are positioned on the anterior and posterior horns. The anterior retractor should be positioned in the tear drop and not in the upper part of the anterior horn (Figure 4). This retractor could injure the psoas tendon if it is too high. The anterior retractor must be held with control to avoid a fracture of the anterior horn. To avoid injuries of the soft tissue or the femur, the reamer must be positioned in the acetabulum by sliding on the posterior retractor.

The soft tissue is usually not injured by the reamer arm, because the acetabulum is in the axis of the scar. Only with a bikini scar, the surgeon must protect the skin to avoid injuries.

Acetabulum preparation

In DAA, the reamer is in the axis of the scar, allowing a lower abduction and an appropriate anteversion of the cup without specific instrumentation, compared to PLA. The preparation follows the same rules as in the posterior approach, with a standard straight cup reamer and impactor (Figure 5). The femur is occasionally in front of the acetabulum and impedes the way for the reamer. That is why the posterior retractor must be positioned well to push the femoral neck back. Two tricks can improve the preparation of the acetabulum. Firstly, after the femoral osteotomy, it is important to perform a femoral release, with a posterior and lateral capsulotomy around the greater trochanter (Figure 6). Secondly, a slight traction of the leg with external rotation by the assistant can open the space in front of the acetabulum. The depth of the reaming is assessed as usual.

Cup positioning

Supine position in DAA changes the three-dimensional orientation of the acetabulum relative to the surgeon and needs to be taken into consideration when transitioning from the posterior approach. There are two major advantages of the supine position: it creates less alteration of the pelvic orientation than the lateral decubitus position and allows intra-operative fluoroscopy.

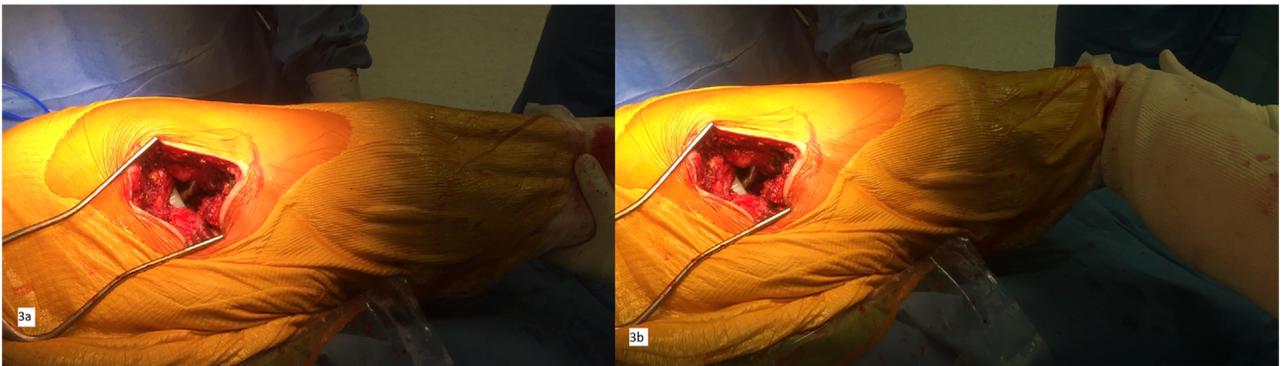


Figure 3. Intra-operative DMC testing with the posterior approach. (a) Test with the knee fully extended showing the “piston sign”. (b) Test with the knee flexed at 90° of flexion showing the disappearance of the “piston sign”.

Table 4. Tips and tricks for anterior approach

Soft tissue management	<ul style="list-style-type: none"> • Capsulectomy must be performed. • The reflected head of rectus femoris can be released at the superolateral part of the acetabulum.
Acetabulum preparation	<ul style="list-style-type: none"> • The anterior retractor should be positioned in the tear drop and not in the upper part of the anterior horn. • A femoral release after the femoral cut is key in improving acetabular exposure. • A slight traction of the leg can open the space to pass the reamer.
Cup positioning	<ul style="list-style-type: none"> • Keep a sufficient anteversion to avoid psoas impingement. • Intra-operative fluoroscopy confirms appropriate positioning of implants.
Intraoperative testing	<ul style="list-style-type: none"> • The use of a standard Table allows an efficient intraoperative test of the hip, similar to a posterior approach.



Figure 4. Two Hohmann retractors are positioned in the tear drop and on the posterior horn.

The hemispheric characteristic of DMCs can cause difficulties during the implant positioning. A good exposure of the bone landmarks is key. Following our experience with psoas impingement on the large rim of the DMC, we have been careful to keep sufficient anteversion, maintaining the mean anteversion equal or greater than 25°. The acetabular cup is placed manually according to the anatomical landmarks: the transverse acetabular ligament is used to control acetabular depth, height and version, the inclination is assessed by orientating the cup flush in line with the roof. The anterior and posterior horns help with the anteversion.



Figure 5. For the direct anterior approach, the straight cup reamer is in the axis of the scar.

Intra-operative fluoroscopy is used to confirm appropriate positioning of implants (Figure 7).

Intraoperative testing

The use of a standard table allows performing an efficient intraoperative test of the hip, similar to a posterior approach. The surgeon can assess the anterior stability in all amplitudes, the range of motion, and potential impingement with the greater trochanter or with the ischium (Figure 8). The anterior stability of the hip must be tested in hyperextension and external rotation.

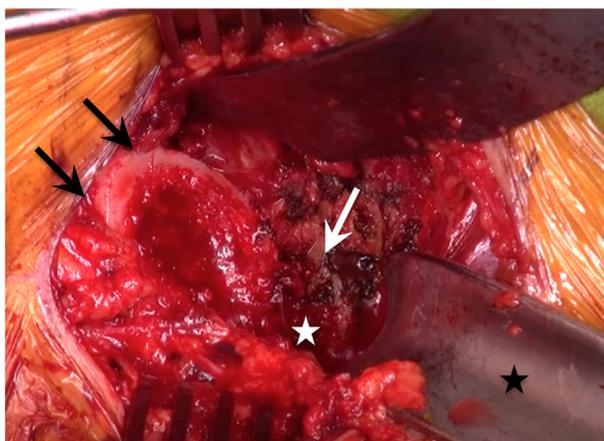


Figure 6. After the femoral osteotomy, it is important to perform a femoral release, with a posterior (white arrow) and lateral capsulotomy (white star) around the greater trochanter (the black arrows show the calcar).

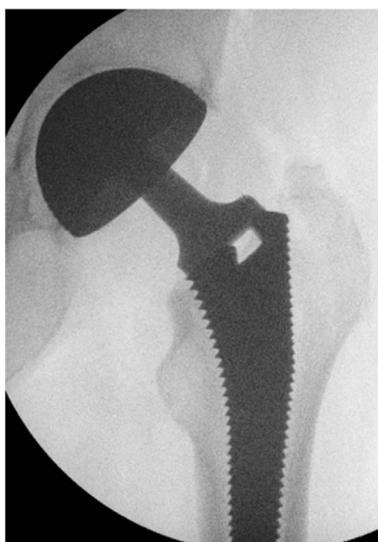


Figure 7. Intra-operative fluoroscopy is used to confirm appropriate positioning of implants.

DMC complications management

DMC is not without complications. Possible complications include dislocation, loosening, intraprostatic dislocation, infection, and impingement (Table 5).

Dislocation

Although the rate of dislocation is very low or even nil in primary DMC DHA, the etiologies associated with gluteal muscular deficits (mainly revision and tumor surgery) have shown a non-zero rate of dislocation [23, 36]. It seems to us essential to know the specific modalities for the reduction of a DMC THA dislocation. This reduction must be performed under general anesthesia while the patient is also neuromuscularly relaxed,

as reduction is generally more difficult than for a conventional cup because of the size of the liner. The contact between the liner and the cup during the reduction maneuver can cause a decapsulation of the liner, which we call “traumatic” intraprostatic dislocation [37–43]. This anti-dislocation device can turn into an anti-reduction device in special circumstances (anterior approach, revision with cage), sometimes requiring an open reduction. In the extremely rare case of early recurrence of a dislocation, we recommend the use of a removable above-knee hip spica cast for one month to allow the soft tissues to heal and to aid hip stability. We also recommend this one-month cast in case of gluteal muscle dysfunction (tumor surgery or revision with trochanter defect). The gluteus medius muscle is essential to the stability of the hip. For the same reason, the muscle transfer described by Whiteside seems to give excellent results in extreme cases (megaprosthesis, paraplegic patient) [44].

Infection

Concerning infection, the rates associated with DMC are equivalent to the rates of other hip arthroplasty concepts. However, it should be noted that the population with the highest proportion of DMC also happens to be the population most at risk of dislocation, i.e. the elderly population, traumatic etiology and revision, which are populations that are at a higher risk of infection. In the case of early infection, Debridement, Antibiotics and Implant Retention (DAIR) is relatively straightforward with a DMC [45]. After synovectomy and lavage, a change of the modular components is performed. After dislocation of the hip and uncoupling of the Morse taper from the stem, a new head-liner pair, prepared on the “clean” operating table is implanted.

Aseptic loosening

Loosening rates are not different from other concepts in the literature, with wear rates closer to cemented Charnley type metal-PE pairs than uncemented metal-PE pairs [46–54]. The cup survival rate for the historical series was greater than 90% at 25 years [10]. This rate seems to be higher for recent implants, using cups with macrostructures and titanium-hydroxyapatite coating, which according to some authors constitute the second generation of dual mobility implants [8, 14, 15, 17, 55]. DMC revision implants also do not have a higher loosening rate than other series, with competitive dislocation rates [23, 56].

Intraprostatic dislocation

IPD, caused by wear of the retention collar, is the specific complication of DMC [28, 57, 58]. In historical series, this rate was around 4% and occurred before 10 years since the index operation [1, 10, 57, 58]. The recent series no longer include this complication, with more than 15 years of experience. Modifications to the design of the collar, improvement in the properties of the polyethylene, combined with a compatible DM-stem association (thin polished neck that is trapezoid, elliptical or circular in shape) have probably led to this probable



Figure 8. The surgeon can assess the anterior stability in extension and external rotation (a), the range of motion and an eventual impingement (b).

Table 5. Tips and tricks for DMC complications management.

Issues	Solutions
DMC THA dislocation	Reduction under General Anaesthesia ± neuromuscular relaxation
Two consecutive dislocations or major deficit of the gluteal muscles	Removable above-knee hip spica cast for one month
Instability despite above-knee hip spica cast	Whiteside transfer
Traumatic intraprostatic Dislocation	Surgical revision with liner exchange
Early infection	Surgical revision for DAIR with head+liner replacement
Avoid loosening	Respect the patient's anatomy

disappearance [28]. However, one should always keep in mind the traumatic IPD.

Surgical treatment is necessary as soon as the diagnosis is made. For traumatic IPD, an open reduction with a liner exchange is required. For IDP due to liner wear, at the minimum, the acetabular cup and the bearing (femoral head and liner) must be exchanged, in combination with a synovectomy [59, 60].

Impingement

With regard to the impingement, the mobility of the liner prevents it from causing rigid contact with the soft tissues. Impingement can only occur between the cup and the soft tissue, mainly the psoas muscle, or between the neck and the cup.

As DMC requires a thin neck for collar retention purposes, the neck-cup impingement seems anecdotal to us, unless the femoral stem is poorly positioned. This is unlikely to have consequences, as Dual Mobility is not subject to a restricted Lewinnek safe zone. To avoid contact with the psoas, the same instructions must be followed as with a conventional cup, i.e. avoid anterior overhang and oversizing [5, 60].

Conclusion

This paper provides advice and recommendations for orthopedic surgeons using DMC. The forty years of history since the introduction of DMC have demonstrated its contribution to hip prosthetic surgery, and they have also allowed for refinement of the appropriate indications for its use and the procedure to follow in the event of a complication. With recommendations

and evidence from the literature, combined with our experience, these guidelines will allow for a surgeon, not confident with the use of DMC, to safely start using it.

Conflict of interest

RP and FF receive royalties from SERF (Décines, France). SL declares the following conflicts of interest: consulting (Stryker), institutional research support to Corin and Amplitude.

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