Review article
Surgical management of recurrent dislocation after total hip arthroplasty
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ABSTRACT
Dislocation is a major complication of total hip arthroplasty (THA), whose frequency has been unaffected by improvements in surgical techniques and implants. The dislocation rate depends on multiple factors related to the patient, hip disease, and surgical procedure and is therefore also dependent on the surgeon. The many published studies on THA dislocation, its causes, and its treatment have produced conflicting results. The objective of this work is to review the management of THA dislocation, which is a severe event for both the patient and the surgeon. This lecture starts with a brief review of data on THA dislocation rates and the many factors that influence them. Emphasis is then put on the evaluation for a cause and, more specifically, on the challenges raised by detecting suboptimal cup position. Next, reported techniques for treating THA dislocation and the outcomes of each are discussed. Finally, a management strategy for patients selected for revision surgery is suggested.

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1. Introduction
Dislocation remains a major complication of total hip arthroplasty (THA). Dislocation is the third leading reason for revision THA overall, after loosening and infection, and is probably the most common reason for early revision THA [1–3].

THA is widely perceived by the public as producing excellent outcomes that usually allow a return to previous activities. Dislocation is viewed by both patients and surgeons as a serious complication, with good reason since the risk of recurrence after a first episode is approximately 33% [4].

2. Dislocation rates, cause, and time to occurrence
Studies of primary THA found dislocation rates of 1.7% [5], 4.8% (of 6623 cemented THAs with 22.2-mm femoral heads) [6], and 0.3% to 10% [2]. Revision THA was followed by higher dislocation rates of 5.1% to 14.4% in one study [7] and 28% in another [2]. Counting subluxation episodes in addition to dislocations would produce even higher rates. Subluxation is difficult to diagnose and therefore frequently overlooked, a fact that hinders an exact evaluation of its incidence rate, which has been estimated at 2–5.5% [4].

Dislocation rates vary with many factors including the following:

- the surgical approach and femoral head size, as discussed below;
- follow-up duration (6% after 20 years and 7% after 25 years) [6,8];
- and many other factors such as [6] female gender, advanced age, specific causes (avascular necrosis of the femoral head, proximal femoral fracture or non-union) [6], obesity [9], co-morbidities with an ASA score of 3 or more [10], neuromuscular impairments (e.g., Parkinson’s disease or stroke-related impairments), neuro-cognitive impairments (e.g., psychiatric disease or mental disability), and exposure to neurotoxins (e.g., alcohol abuse). Finally, the dislocation rate is higher in patients with a history of surgery on the same hip, most notably previous THA procedures [10].

Although most dislocations occur early after THA, the dislocation rate increases with follow-up duration. Three categories can be defined based on time to occurrence [4]:

- early dislocations within the first 3 (or 6) months after THA are the most common (50 to 70%) [4]) and are promoted by inadequate healing;
- secondary dislocations occur after the resumption of previous activities, between 3–6 months and 5 years after THA, in relation to increased hip mobilisation; this category contributes 15 to 20% of all THA dislocations;
- and late dislocations, occurring more than 5 years after THA, are often related to polyethylene wear; their rate may be underestimated [4] and may reach 32%, with a mean time to occurrence of 11.3 years.

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3. Evaluation of the unstable THA

The prerequisite to developing an appropriate treatment strategy is a thorough evaluation to identify the causes of the dislocation.

The direction of the dislocation should be assessed based on the causative movement, femoral head position on the lateral view (which unfortunately is often not obtained) (Figs. 1 and 2) and, above all, direction of the instability as determined during reduction.

In addition to the above-listed risk factors, many factors that contribute to THA dislocation are related to the surgical technique, including the following:

- surgical approach;
- component orientation;
- femoral head diameter;
- restoration of femoral offset and leg length;
- cam impingements;
- condition of the soft tissues.

3.1. Surgical approach

The postero-lateral approach is associated with a higher dislocation rate (mean, 6.9% [2,8,11]) compared to the antero-lateral approach (3.1% [8]) and anterior approach (0.6 to 1.3% [2]).

3.2. Component orientation

Suboptimal component position often results in early or secondary dislocation but may be difficult to demonstrate.

3.2.1. Cup

Lewinnek et al. [12] defined a safe zone of 40° ± 10° of inclination and 15° ± 10° of anteversion. However, many patients have cups outside this safe zone yet do not experience dislocation [2,13]. A cup that is too vertical and/or anteverted increases the risk of anterior dislocation, whereas a cup that is too horizontal and/or insufficiently anteverted increases the risk of posterior dislocation. Inclination can be reliably measured on a standard radiograph, whereas anteversion cannot. Although numerous radiograph and computed tomography (CT) protocols have been developed, the values often differ between two measurements (Figs. 3 and 4). Several groups [14,15] have therefore developed CT measurement protocols that take into account the degree of pelvic tilt measured on a standing lateral radiograph and involve measurements of anteversion in the lying, sitting, and standing positions. This point is important, as the orientation of the pelvis and, therefore, of the cup, changes with body position. The influence of pelvis position...
in the sagittal plane has been assessed in many studies, including those conducted by Lazennec [15].

Thus, before diagnosing suboptimal cup position in a patient with one or more dislocation episodes, the measurement protocol must be considered. Failing this precaution, overdiagnosis of cup malposition may occur, prompting an inappropriate surgical procedure that is unlikely to produce a good outcome; or, on the opposite, cup malposition may be overlooked.

Navigation may optimise component positioning, producing substantially lower proportions of cups outside the safe zone compared to conventional surgery, as demonstrated in a prospective study reported by Parratte et al. in 2007 [16]. However, difficulties in identifying the anatomic landmarks used to determine the anterior pelvic plane, together with the considerable variability in this plane [17], have prompted some groups to use navigation based on joint kinematics [18].

One means of obviating the need for navigation may consist in positioning the infero-medial cup rim parallel to the transverse acetabular ligament. In the hands of a Japanese group, this method produced 21.2° of mean anteversion, with no significant difference between patients with and without hip dysplasia [19]. The combined anteversion of the cup an the femoral component is important (35 ± 10°) [20].

3.2.2. Femoral component

Anteversion of the femoral component is easier to determine, by measuring the angle between the prosthetic neck axis and the line tangent to the posterior femoral condyles on a CT scan. This value often differs from the surgeon’s estimate, by a mean of 16.8° according to a study by Dorr et al. [20].

3.3. Femoral head diameter

Femoral head diameter influences the stability of the prosthetic joint. In a study by Berry et al. [8], femoral heads measuring 22 mm in diameter were associated with higher dislocation rates; however, the posterior approach was used in most patients. In a study of 2020 THAs performed via the antero-lateral approach with heads measuring 36 mm or more in diameter, Lombardi et al. [21] identified a single case of dislocation (0.05%) after a mean follow-up of 31 months. Howie et al. [22] conducted a prospective randomised controlled trial to compare 28-mm to 36-mm heads implanted via the postero-lateral approach. The dislocation rate was five times

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higher with the smaller heads. A larger head diameter increases the head/neck ratio and delays contact between the neck and the cup. In addition, the ‘jumping’ distance is increased, allowing for a greater range of ‘subluxation’ before complete dislocation occurs [23].

3.4. Restoration of femoral offset

This point is crucial to hip stability, mobility, and optimal abductor muscle efficiency. Femoral offset measured on radiographs varies with femoral anteverision. Merle et al. [24] reported underestimation of femoral offset on antero-posterior pelvic radiographs, with improved accuracy on antero-posterior hip radiographs. Navigation and 3-D pre-operative planning may improve restoration of the native offset [25].

3.5. Restoration of leg length

Leg length restoration also improves stability, by maintaining muscle tension. A clinical and radiological evaluation of leg length, although mandatory, is associated with numerous pitfalls and errors, most notably in patients with a contra-lateral prosthetic hip.

3.6. Cam impingements

Contact between the neck and cup is the most common form. A smaller head and wider neck are associated with earlier neck-cup contact during hip movements. A femoral head skirt or prominent cup lip increases the risk of contact.

Unwanted contact may also occur between the neck and an osteophyte, a cement fragment, or hypertrophied or ossified soft tissues. When medialised, the femoral metaphysis can contact the pelvis, either directly or through the soft tissues, producing cam impingement [4].

3.7. Condition of the soft tissues

Soft tissue damage (failed healing of a posterior or anterolateral approach) explains many dislocations but is difficult to demonstrate before revision surgery. Healing failure rates increase with the number of surgical procedures. Non-union of the greater trochanter results in slackness of the abductor muscles, thereby increasing the risk of dislocation, most notably when the greater trochanter is displaced upwards.

Thus, THA instability can be related to a single cause, and the treatment is then relatively easy. In most cases, however, multiple factors are involved, which complicates the therapeutic management [4].

4. Stabilisation techniques

4.1. Changing a component or modular components

Suboptimal component position usually involves the cup, as found in 33% of cases by Morrey [26]. When poor position is demonstrated, changing the component is a logical procedure that has produced highly variable success rates. A 2-year success rate of 69% after cup revision was reported in one study [26], whereas Carter et al. [27] obtained a higher success rate of 86% but often increased the head diameter (36 mm) in addition to changing the cup. Changing a poorly positioned femoral component is desirable but considerably more invasive than cup revision; in the study by Carter et al., this procedure was performed in only 11.5% of 156 hips.

Changing only the liner may carry an even higher failure rate, of 34% to 55% in the study by Carter et al. [27], as a result of unrecognized suboptimal cup position. In contrast, Tooney et al. [28] reported successful stabilisation of 10/13 hips 5.8 years after modular component exchange (shallower head allowing an increase in neck length, increased head diameter, liner with an elevated rim, or lateralised liner). However, the patients were carefully selected, in particular based on absence of malposition. A modular neck increases the range of adaptation options.

4.2. Systems that increase cup depth

Cups with elevated rims were first suggested by Charnley as early as 1979 [4]. Liners with elevated rims are now available for insertion into cementless cups. Although these liners decrease the dislocation rate [29], they also place considerable mechanical stresses on the cup and can result in cam impingement.

Polyethylene lip augmentation devices (Fig. 5) are either partial or complete (Fig. 6) and may have a metal backing plate; they allow THA stabilisation while keeping the same cup and requiring only a short operative time. McConway et al. [30] reported a 1.6% recurrence rate in 302 cases after a mean follow-up of nearly 7 years and with less than 2% of radiolucent lines accentuation. However, similar to elevated-rim cups, or perhaps even to a greater extent, lip augmentation devices are associated with cam impingements, increased mechanical stresses on the cup, and weakening of the polyethylene by the screw trajectories. In addition, complete lip augmentation devices decrease prosthetic clearance by 40% [4].

4.3. Constrained cups

Constrained cups were developed several years ago. Their modern cemented version was designed by Lefèvre (Fig. 7A-B) in France.

In a study by Hernigou et al. [31], constrained liners proved highly reliable in preventing dislocation in patients with neurological or cognitive impairments. After a mean follow-up of 7 years, the dislocation rate in 164 hips was only 2% (compared to 25% with standard prostheses and hemi-arthroplasties), and a single patient had required revision surgery for loosening. In theory, constrained cups allow 122° of mobility with a 28-mm head. Their efficacy in the treatment of THA dislocation has not been assessed.

In a case-series study by Berend et al. [2] of 755 constrained cups (usually implanted during revision surgery), the outcomes were unsatisfactory, with 5- and 10-year prosthesis survival rates of only 68.5 and 51.7%, respectively, and a dislocation rate of 17.5% overall.
and 28.9% after revision for recurrent dislocation; in addition, cup and femoral head loosening occurred in some patients. Outcomes were substantially better with a cup allowing for 110° of mobility before contact with the neck, which provided a success rate of 11/12 (92%) in patients with recurrent dislocation, but with a follow-up of one year. Noble et al. [32] examined 57 constrained cups of four different designs recovered during THA revision surgery performed 36 months on average after the primary procedure. Locking ring failure explained 51% of revisions and cup loosening a further 28%. Similar to Berend et al. [2], the authors concluded that constrained cups cannot ensure long-term stability unless the range of motion before neck impingement can be increased.

4.4. Tripolar constrained cups

Tripolar constrained cups, which are used in the US, comprise a mobile cup that articulates with a polyethylene cup equipped with a locking ring (Fig. 8). The constrained cup can be inserted into a cementless metal cup or secured to the acetabulum itself or, more rarely, placed into a securely fixed metal cup. The decreased thickness required by this design may be associated with diminished survival.

In a prospective study conducted by Khan et al. [33] in 34 patients, 97% of hips were stable after 3 years but 11.8% showed evidence of cup loosening. The Trident (Stryker®) constrained cup used in this study, usually without cement, allows for only 88° of prosthetic clearance.

Guyen et al. [34] studied 389 hips with tripolar constrained cups (Osteonics®) and a mean follow-up of 28.4 months. The overall

![Fig. 6. Complete lip augmentation device in a left total hip arthroplasty.](image)

![Fig. 7. A. Constrained cup. B. The mechanism.](image)

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failure rate was 11% and the mechanical failure rate was 8%, with involvement of the various cup interfaces or of the locking ring. These authors felt that the failure rate was underestimated, as some patients with failed prostheses had satisfactory hip function.

Tripolar constrained cups should be reserved for salvage surgery in the most difficult cases.

4.5. Unconstrained tripolar cups

The principle of the unconstrained tripolar cup was developed by Bousquet (Fig. 9) then used by many different manufacturers. A 22- or 28-mm head is held captive in a polyethylene cup, which is mobile within a cemented or press-fit metal cup made of steel or cobalt-chromium (Fig. 10). Either standard or highly reticulated polyethylene is used, and the head can be made of ceramic. The intermediate component is made of ceramic in some models.

Outcomes after the implantation of dual-mobility cups for THA instability have been evaluated in numerous studies, of which the earliest was conducted by Leclercq et al. [35]. After 2.5 years of follow-up, 13 hips with recurrent dislocation were stabilised without correction of the causes of the instability. Mertl et al. [36] studied 59 cases and found a 1.7% recurrence rate and a 98% 8-year survival rate. In 54 cases, Guyen et al. [37] reported a 5.5% recurrence rate after a mean follow-up of 4 years and in 47 cases Hamadouche et al. [38] recorded a 4% recurrence rate after 6 years.

Dual-mobility cups are now very widely used to prevent instability after revision THA. In a prospective study of 2107 revision THAs including 62% with dual-mobility cups, Delaunay et al. [39] found a 3-month dislocation rate of only 4%.

Enthusiasm about these very good results must be tempered by knowledge of the fixation problems seen with press-fit dual-mobility cups. Massin et al. [40] found a lower 8-year survival rate of press-fit grit-blasted cups made of hydroxyapatite-coated steel, compared to the original tripod cup and to cobalt-chromium cups (91% versus 98% and 100%, respectively). Mertl et al. [36] have recommended cups with hydroxyapatite surface treatment over a porous metallic substrate.

Finally, the deeper concavity of dual-mobility cups is associated with greater wear [23], which carries a risk of intra-prosthetic dislocation due to locking system failure. Mean time to intra-prosthetic dislocation is 10 years. The risk of this complication can be minimised by avoiding neck-cup impingement and is extremely low with the newest generation implants [23,40]. Nevertheless, even with the original tripod cup, 15-year survival rates were greater than 85% in the long-term studies by Philippot et al. [41] and Lautridou et al. [42], each of which included more than 400 cases.

4.6. Large-diameter femoral heads

As indicated above, large-diameter heads are associated with decreased dislocation rates [8,21–23] and are therefore useful for the treatment of THA instability (Fig. 11). For a given neck diameter, stability increases with the diameter of the femoral head up to 38 mm; with larger diameters, variable results have been reported [43].

In a study by Amstutz et al. [44] of 29 THA revisions for dislocation managed with head diameters of 36 mm or more, the recurrence rate was 13.7%. Suboptimal cup orientation was noted.
in the six hips with persistent instability; after correction of cup position, none of the hips was unstable after a mean follow-up of 5.5 years.

Several studies found markedly lower dislocation rates after revision THA for reasons other than instability: 1.8% [44], 4.9% [25], and 1.1% with 36- or 40-mm heads versus 8.7% with 32-mm heads after a mean follow-up of 5 years [45].

Most of the available studies focussed on the impact of large head diameter on primary THA stability and wear debris volume. They used various friction couples for which the medium- and long-term outcomes are unclear. With metal and either standard or highly reticulated polyethylene, volumetric wear increased, particularly with heads larger than 36 mm in diameter [36], whereas linear wear was unchanged. However, Hammerberg et al. [46] reported that the annual volumetric wear rate, although increased 2-fold with head diameters of 38 and 44 mm, remained far below the values associated with osteolysis (29.1 ± 14.8 versus 80 mm³/year).

Using metal-on-metal implants, Mertl et al. [47] obtained good 30-month outcomes with dislocation (due to trauma) in only 1.8% of 106 patients. Nevertheless, unexplained pain was noted in 4.7% of patients. Bosker et al. [48] reported a high pseudo-tumour formation rate of 39% in a series of 108 hips, with a 12% revision rate, and identified adverse reaction to metal debris as the main cause. Ceramic-on-ceramic implants release very few wear particles, which are extremely well tolerated. Nevertheless, heads greater than 36 mm in diameter require a decrease in liner thickness, which increases the risk of rupture. In addition, even with composite ceramics, a number of problems persist, such as squeaking; subluxation during hip movements responsible for micro-separation and edge-loading, which in turn may cause fractures; and increased loading at the bone-cup interface due to eccentric positioning of the head centre, which can result in cup tilting [23].

4.7. Restoration of soft tissue tension and elimination of impingements

These procedures are consistently used in combination with the above-described techniques:

- capsular plication, trans-osseous soft tissue repair, or even plasties involving the implantation of allografts or a mesh to generate fibrosis, which may be useful in patients with severe soft tissue deficiency [2];
- lowering of the greater trochanter (by 18 ± 6 mm), which can be very helpful in stabilising the THA by re-tensioning the abductor muscles and increasing their lever arm, provided the components are properly positioned. Hook plates facilitate the procedure (Fig. 13). Nevertheless, non-union can occur. In an analysis of four published case-series, Morrey [29] found a 73% success rate (54 of 74 hips);
- treatment of greater trochanter non-union is crucial to ensure stability and function. However, healing may be difficult to obtain, despite the availability of improved internal fixation devices and the use of bone grafts. Factors that can compromise healing include gluteus medius and minimus contracture, which is a common abnormality; fragility of the trochanteric fragment; loss of bone from the lateral metaphysis; and the high loads placed on the fixation. After the procedure, weight-bearing

Fig. 11. Large-diameter heads. Top row: metal; bottom row: Ceramic (Biolox).
With permission from Tornier Inc.

Fig. 12. Removable cones.
With permission from Amplitude Inc.

Fig. 13. Hooks for fixation of the greater trochanter.
With permission from Zimmer Inc.
ambulation is allowed with two forearm crutches for 4 months [4] (Fig. 14).

4.8. Post-operative immobilisation

Post-operative immobilisation regimens vary widely. The goal is to promote soft tissue healing. Post-operative immobilisation is less often used after revision THA than after closed reduction.

Available methods include suspension traction, a pantaloon or hemi-pantaloons cast made of resin (or with a removable version), an abduction pad, and a knee brace.

Many groups recommend immediate ambulation and rehabilitation using appropriate methods after revision surgery for THA dislocation [3,21,22,39]. Others advocate tailoring the immobilisation regimen based on a number of criteria such as the surgical approach and patient-related factors [49].

5. Indications [2,4,26,28,47,49]

Surgical treatment for THA instability is usually considered after the second or even the third dislocation episode, in patients without obvious component malposition, failed closed reduction, or significant greater trochanter displacement.

5.1. Cup malposition, wear, or loosening

In a patient who is younger than 70 years of age and has no risk factors, the cup should be changed and properly positioned. If allowed by the implants, the head diameter should be increased. In cases of isolated wear, a change of liner, with a preference for an elevated lip design, deserves consideration.

In patients who are older than 70 years and/or have risk factors for instability (multiple surgical procedures or neurological impairments for instance), a dual-mobility cup seems the best solution.

A constrained cup may be considered, particularly in the oldest patients.

Brogan et al. [50] has described a technique involving milling of a well-fixed polyethylene cup with preservation of the cement, in which holes are made for fixation of the new cup. This technique spares the bone stock and decreases the invasiveness of the revision procedure. Similarly, in patients who have a well-fixed cementless cup, a polyethylene cup can be cemented in the appropriate position. The 5-year survival rate with this method was 78% in a study by Beaulé et al. [51].

5.2. Appropriate cup position with no wear or loosening and no femoral cause of dislocation

With a cementless cup, the liner can be exchanged for an elevated-lip liner and the head diameter can be increased if allowed by the implants. With a cemented cup, a lip augmentation device can be considered. In young patients, however, a change of cup with an increase in head diameter seems preferable.

A dual-mobility cup can be considered also, chiefly in patients older than 60 years of age.

5.3. Femoral cause of THA dislocation

In the event of inadequate femoral offset or excessive anteversion or retroversion, replacement of the femoral component should be considered.

A lateralised component or a component with a greater degree of varus is usually required to restore offset. A less invasive means of restoring offset consists in changing the length of the neck and/or the diameter of the head (if the cup liner can be changed); care should be taken, however, to avoid excessive shortening of the lower limb.

When the primary THA includes a removable neck, this component alone can be changed, and its length and orientation can be modified. When changing a femoral component, the use of a removable neck design can be considered to optimise anteversion, offset, and neck length.

The stem should be changed if it is loose or unstable.

5.4. Soft tissue repair

The soft tissues must always be repaired to the extent possible. In addition to the above-described procedures, suturing the fascia lata to the greater trochanter and vastus lateralis muscle with the hip in abduction is useful.

A fracture or non-union of the greater trochanter should be treated.

When no cause is identified, lowering of the greater trochanter can be considered but carries a risk of non-union.

5.5. Immobilisation

Immobilisation can be helpful in patients with severe soft tissue alterations or with factors such as agitation or poor motor coordination.

6. Conclusion

Recurrent dislocation after THA is difficult to treat and poses a major challenge to surgeons. Although most cases are multifactorial, every effort should be made to identify a predominant cause, whose treatment will provide an optimal outcome.

When the need for surgical treatment has been established based on a comprehensive evaluation of the instability, the surgeon must make sure that all the material needed is available and
appropriate for the current prosthesis. Implant exchange is usually needed and is more often partial than complete. The decision rests on the pre-operative data and findings at revision surgery. Even when an apparent cause is identified, there should be no hesitation in combining several stabilising procedures, such as a change in cup position, the use of a larger femoral head if allowed by the implant, correction of inadequate femoral offset, and anteversion or femoralisation. Soft tissue repair should be performed routinely.

The objective is to avoid further dislocation, a devastating event whose frequency increases with the number of surgeries on the hip.

Prevention remains the best treatment.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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