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REVIEW

Dislocation of primary total hip arthroplasty: Analysis of risk factors and preventive options

Dario Regis, Mattia Cason, Bruno Magnan

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Dario Regis, Mattia Cason, Bruno Magnan, Department of Orthopedic and Trauma Surgery, Integrated University Hospital, Verona 37126, Veneto, Italy

Corresponding author: Dario Regis, MD, Adjunct Professor, Department of Orthopedic and Trauma Surgery, Integrated University Hospital, Piazzale Aristide Stefani 1, Verona 37126, Veneto, Italy. regisdario@siot.it

Abstract

Total hip arthroplasty (THA) is one of the most successful elective operations in orthopedic surgery for improving pain and functional disability in patients with end-stage joint disease. However, dislocation continues to be a troublesome complication after THA, as it is a leading cause of revision and is associated with substantial social, health, and economic costs. It is a relatively rare, usually early occurrence that depends on both the patients' characteristics and the surgical aspects. The most recent and important finding is the special attention to be given preoperatively to spinopelvic mobility, which is closely related to the incidence of dislocation. Consequently, clinical and radiographic assessment of the lumbar spine is mandatory to identify an altered pelvic tilt that could suggest a different positioning of the cup. Lumbar spinal fusion is currently considered a risk factor for dislocation and revision regardless of whether it is performed prior to or after THA. Surgical options for its treatment and prevention include the use of prostheses with large diameter of femoral head size, dual mobility constructs, constrained liners, and modular neck stems.

Key Words: Dislocation; Total hip arthroplasty; Revision surgery; Review; Risk factors; Complication

Core Tip: Total hip arthroplasty (THA) is a common and highly effective elective procedure in orthopedic surgery. Postoperative dislocation is a disabling and challenging complication that affects patient outcome and remains one of the leading causes of early revision surgery. This review provides a detailed analysis of the multifactorial causes of dislocation following primary THA. The surgical options that may prevent or minimize this risk are also presented and discussed.

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INTRODUCTION

Although total hip arthroplasty (THA) is considered the operation of the last century[1], with survivorship of 77.6% up to 25 years[2], some complications may occur and affect the final outcome. In a systematic review and meta-analysis of 125 studies involving approximately five million primary hip replacements, the average incidence of dislocation was less than 3%, ranging from 0.12% to 16.13%, over a mean follow-up of 6 years, and more than half occurred in the first 3 mo after surgery[3]. According to the joint replacement registries, it is one of the most common reasons for revision of a hip prosthesis, ranging between 9.2% and 31.7%[4-6] (Table 1).

Therefore, despite technical and technological improvements, the dislocation of a THA is still a cause for concern as it may considerably affect the functional result of the procedure and patient satisfaction, especially in the case of recurrence [7,8]. Moreover, economic consequences should be considered because of the need of further hospitalization and possible revision surgery. In an Italian study, early dislocation has been reported to increase the cost of a primary THA by 342% [9]. The clinical and economic burden of this complication was retrospectively evaluated in England using data from the United Kingdom Clinical Practice Research Datalink database[10]. Patients who dislocated showed 2-year median direct medical costs of £15333 higher than the uncomplicated population. Moreover, they had greater healthcare resource use and less improvement in Euro Qol five-dimension index.

This comprehensive review briefly summarizes the current knowledge on early (< 3 mo) dislocation of a primary and elective hip prosthesis, analyzing contributing factors and discussing preventive options.

RISK FACTORS

Risk factors of dislocation of a THA are usually classified as patient-related (age, sex, body weight, pelvis kinematics, neuromuscular disorders, preoperative diagnosis, anesthesiological risk) and surgery-related factors (surgeon skill and hospital experience, surgical approach, prosthetic components positioning, type of prosthesis).

PATIENT-RELATED

Age

Although in most papers advanced age (> 80 years) is considered a predisposing factor, some studies report a higher risk of dislocation in patients aged > 70 years or under 50[11,12]. However, the Australian Hip Registry shows the protective role for older people, especially females[6].

Sex

Female sex seems to have a higher (double) incidence of this complication compared to the male population[13,14]. In the last edition of the Australian Registry, while men show a constant rate of dislocation over time, women < 55 years double this risk, which decreases almost completely > 75 years[6].

Body weight

Obesity was found to increase the dislocation rate by 113.9% every 10 points of Body mass index (BMI) elevation[15]. BMI values higher than 35 kg/m^2 include a 4.42-fold higher risk than BMI < 25[16].

Sagittal pelvic kinematics

The relationship between alterations in vertebral biomechanics and prosthetic instability is likely to be the most current issue in hip replacement surgery, as the orientation of the acetabular component in the sagittal plane is intrinsically linked to the mobility of the lumbar spine and to the position of the pelvis.

The sacral slope (SS) is an index of the spatial position of the sacrum. Pelvic tilt (PT) consists of the angle between the vertical line passing through the center of the femoral head and the line joining the midpoint of the sacral base with it (normal values: 13° ± 6°). PT changes as the patient's positions change: a higher or lower value indicates a retroverted or anteverted pelvis, respectively. The SS changes with the subject's position inversely with PT, and their sum gives a constant value, that is the pelvic incidence (PI).

PI is a constant morphological parameter for each patient. It reflects the relationship between the position of the sacrum and the femoral head and determines the adaptability of the spinopelvic balance in the sagittal plane, which is reduced in the case of a low PI value.

Table 1 Percentages of main diagnoses causing hip revision as reported in prosthetic registries

Diagnosis associated with hip revision	SAR, *n* = 14625	AOANJRR, *n* = 13098	RIPO, *n* = 17090
Dislocation	12.0	22.0	9.3
Aseptic loosening	42.2	21.0	60.5
Infection	20.2	22.7	1.1
Pain	1.2	1.9	1.8
Periprosthetic fracture	15.3	21.8	7.7
Mechanical complication	0.9	2.4	5.1
Wear	1.7	0.6	4.3

AOANJRR: Australian Orthopedic Association National Joint Replacement Registry; RIPO: Regional Register of Orthopedic Prosthetic Implantology; SAR: Swedish Arthroplasty Register.

When standing, the pelvis rotates forward, so the PT and the acetabular version decrease, whereas the lumbar lordosis increases to allow the center of gravity of the skeleton to align with the center of rotation of the femoral head. Transitioning to a sitting position, the pelvis rotates posteriorly (rolls back), increasing the PT and the acetabular version with a consequent decrease in the lumbar lordosis[17].

This finding has also been confirmed by observational studies by Lembeck *et al*[18], who calculated a variation of 0.7° of the acetabular version for every degree of variation of the PT. Changes in pelvic rotation in the sagittal plane depend on the flexibility of the lumbar spine. Therefore, an appropriate assessment of sagittal pelvic kinematics is essential to define the correct orientation of the acetabular component, preventing impingement, instability and finally dislocation. In the healthy spine, the increase of acetabular anteversion reduces the likelihood of posterior dislocation for two reasons: first, it creates additional acetabular coverage; second, it decreases the probability of anterior impingement in hip flexion [17].

Following lumbar fusion, the increased rigidity prevents the natural roll back of the pelvis while sitting down. The acetabulum is then kept in a retroverted and horizontal position, which promotes the risk of anterior impingement and posterior dislocation. Therefore, in pelvic stiffness, the cup should be placed with increased inclination and anteversion, whereas a hypermobile pelvis should require a position with less inclination and anteversion of the socket[19].

In a comparative study involving patients undergoing THA with or without lumbar arthrodesis, stabilized subjects showed a higher risk of dislocation, with 3% *vs* 0.4% and 7.5% *vs* 2.1% after 1 and 2 years, respectively[20]. A similar result was reported at 12-month follow-up by Perfetti *et al*[21] in patients undergoing lumbar fusion who had an increased risk of dislocation (3.0% *vs* 0.4%) and revision (3,9% *vs* 0.9%) of the prosthesis. In a cohort affected with unoperated sagittal deformity of the spine who underwent THA, dislocation and revision rate was observed in 8% and 5.8% of patients, respectively[22,23].

In a recent clinical study including 22 revisions for instability, Ramkumar *et al*[24] validated a patient-specific quantitative acetabular safe zone component placement algorithm based on spinopelvic parameters and related patient-specific quantitative acetabular and qualitative hip spine classification targets. Patient-specific safe zone targets differed from prerevision acetabular component position by 9.1° ± 4.2° inclination/13.3° ± 6.7° version. After surgery, the mean difference was 3.2° ± 3.0° inclination/5.3° ± 2.7° version. Differences between patient-specific safe zones and the median and extremes of recommended hip-spine classification targets were 2.2° ± 1.9° inclination/5.6° ± 3.7° version and 3.0° ± 2.3° inclination/7.9° ± 3.5° version, respectively.

In 2024, Kouyoumdjian[23] published a comprehensive review on the spinopelvic femoral complex (SPFC), determining the influence of THA on this kinematics and the effect of stiffness of the SPFC on the risk of prosthetic failure. The most important finding was that in sitting position, the pelvis goes into retroversion and the acetabulum opens forward, while the opposite (pelvic anteversion) occurs when a person stands. He concluded that disturbances in SPFC kinematics, leading to abnormal hip function, may contribute to complications following THA.

Therefore, surgeons performing THA should develop algorithms that start with preoperative dynamic spinopelvic biomechanical data to optimize the placement and choice of the prosthetic components to decrease the rate of dislocation.

Neuromuscular disorders

The presence of neuromuscular or cognitive disorders (dementia, muscular dystrophy, spinal cord injury, poliomyelitis, and cerebral palsy) increases the risk of dislocation. In a study performed at Stanford University, 13% of patients who showed this complication in the first 3 mo following THA had brain dysfunction, compared with 3% of the unaffected population[13]. Therefore, these cases should be treated in highly specialized centers[25]. Finally, although THA may be beneficial in selected neurological conditions to reduce pain and improve function, there is an increased risk of associated complications, such as dislocation[26].

Preoperative diagnosis

An increased risk of dislocation is documented in hip disorders as avascular necrosis of the femoral neck, inflammatory arthritis, and neck fractures[27,28].

Anesthesiological risk

Dislocation of a THA is more common in patients with high anesthesiologists (ASA) score (3-4), with a 1.5-fold increase in risk for each point, mainly due to the difficulty of multi-pathological patients to correctly follow postoperative rehabilitation[29,30].

SURGERY-RELATED

Experience of the surgeon and the hospital center

The skill of the surgeon and the experience and the hospital center where the operation is performed affect the incidence of dislocation of a THA. According to a Canadian study, the execution of at least 35 prostheses per year should be considered the threshold value for significantly reducing the dislocation (1.3% *vs* 1.9%) and revision (1.0% *vs* 1.5%) rates [31]. Moreover, Hedlundh *et al*[32] reported that the risk of this complication decreases by 50% for every 10 prostheses performed annually, with no additional decrease over 30 operations.

Analyzing the data provided by the American health system, the incidence of this complication was 1.5% in the hands of specialists (more than 50 operations/year) compared to 4.2% by surgeons who performed five or less procedures[33]. Centers with a high number of hip prostheses (> 110/year) also have a lower chance of dislocation than hospitals that normally perform less than 32 operations[34].

Surgical approach

The posterior approach has been shown to be associated with a higher incidence of dislocation compared to the anterior and lateral accesses, although many surgeons continue to prefer it[5,35].

However, this occurrence is not necessarily correlated with misplacement of the components, as it is more precise[36], but rather with greater damage to the external rotator muscles[37]. In a recent meta-analysis, posterior capsule repair was found to increase joint stability and the Harris Hip Score and to reduce the rate of dislocation and bleeding[38]. Moreover, the risk of reoperation due to dislocation in the first 2 years following posterior compared to lateral access has significantly decreased according to the Swedish Hip Registry[39]. In other studies, the suturing techniques were not effective, showing the failure of repair in 15 out of 20 surgeries[40]. Finally, despite a higher cumulative incidence of revision, the anterior approach is associated with a decrease in dislocation rate[6,41,42].

The analysis of the predisposing factors showed that none is an absolute contraindication for prosthesis, and in each case, risks and benefits must be carefully weighed, providing adequate information especially on the unfavorable results of this surgery.

Due to the relevant correlation between the degree of vertebral stiffness as a para-physiological evolution of a degenerative or post-surgical process, and the increased risk of dislocation, an imbalance in the sagittal plane or a reduced lumbar mobility must be carefully checked preoperatively. Clinical data should be integrated with lateral radiographic assessment of the lumbosacral spine in both the standing and sitting positions to evaluate the change in PT and acquire crucial information for surgical cup placement.

As previously reported, the operation should be performed by an experienced surgeon who implants at least 35 prostheses per year to reduce the possibility of dislocation[33].

PREVENTIVE OPTIONS

Prosthetic component positioning

Cup: The importance of correct positioning of the acetabular component to reduce the risk of dislocation was emphasized in 1978 by Lewinnek *et al*[43], who proposed a “safe zone” considering an optimal inclination of 40° ± 10° and anteversion of 15° ± 10°. Dislocation occurred in 1.5% and 6.1% of the 300 hip prostheses placed inside and outside this area, respectively.

However, the safe zone does not consider the functional position of the patient[44], as the presence of a rigid or hypermobile pelvis involves different orientations between sitting and intraoperative position. Therefore, in patients with hypermobile and rigid pelvis, the cup should be placed with an inclination between 35° and 40° and anteversion of 45°, respectively[19].

The correct positioning of the acetabular component is an important aspect, which could benefit from assisted robotic surgery[45,46].

Stem: Reconstruction of physiological offset and anteversion of the femur is critical for correct functioning and long-term survival of THAs, but femoral anteversion has great variability (from - 5° to + 29°), with a retroversion present in up to 23% of subjects[47], leading to potential conflicts and instability[48].

Using a three-dimensional computer-aided design model, Seki *et al*[49] identified an optimal anteversion angle of the stem of 10°. However, a new concept of combined anteversion of both the prosthetic components between 25° and 50° was later proposed[50]. This aspect is particularly relevant with cementless stems, which include limited anteversion changes to obtain an adequate press-fit, with less possibility of adapting to morphological variability[51]. Especially with the use of anatomical or neck-preserving stems, the possibility of a wider proximal modularity is extremely useful[52]. However, restoration of the femoral offset is not crucial to prevent joint instability according to a recent systematic review [52].

TYPE OF PROSTHESIS

The selection of the prosthetic components plays a critical role in reducing the risk of dislocation. The main surgical options are briefly summarized thereafter.

Dual mobility cups

The most recent meta-analyses demonstrated the ability of dual mobility (DM) cups to considerably reduce the risk of dislocation of a THA[5,53]. This type of implant, which was introduced between 1974 and 1979 by Gilles Bousquet, combines the advantages of the reduced wear of polyethylene (PE) provided by the low friction arthroplasty described by Charnley with the stability of the large diameter of the McKee-Farrar prosthesis[54].

The DM system consists of two joints, including one with a large diameter between the metal back and PE insert, and a smaller one between the PE and femoral head. The two joints never move simultaneously, resulting in an increase in the range of motion and the jumping distance compared to standard prostheses[55]. A great advantage of this model is that the insert acts like a spring, which prevents the transmission of shear forces to the metal back from the head, thus preserving and theoretically decreasing the risk of cup loosening.

However, a greater rate of PE wear must be considered, exceptionally leading to intraprosthetic dislocation, a specific complication requiring surgical reduction[56]. Moreover, a higher incidence of periprosthetic fractures and failure compared with standard cups have been reported, especially in young patients[5,6,57,58].

Constrained liners

Constrained liners have been traditionally used in the revision of unstable prostheses[59]. They have a locking mechanism that creates a mechanical bond with the prosthetic head that prevents dislocation[60].

Unfortunately, due to the transfer of destabilizing stresses to the entire acetabular system, a higher incidence of aseptic loosening than conventional cups has been reported[61].

Large diameter femoral heads

Data from joint registries demonstrate the protective role of large diameter heads against dislocation[6,62].

From a biomechanical point of view, this option increases the head-neck ratio and the jumping distance, thus decreasing the risk of intraprosthetic conflict, which could be responsible for early THA failure due to greater wear or the breakage of the PE and ceramic inlays, respectively[63,64].

Diameters greater than 32-36 mm have been shown to negate the benefits on joint movement while increasing disadvantages, such as the fragility of thinner inserts, surface wear, and higher fretting and corrosion phenomena[65,66].

Modular stems

Since the mid ‘80s, femoral stems with modular necks have been developed to allow an easier and independent restoration of parameters as offset, limb length and anteversion, which deeply affect THA biomechanics.

Despite these attractive theoretical principles and some excellent clinical results[67], the modularity of the neck has never reached full consensus because of the higher revision and dislocation rate reported by hip registries[6,68].

Robotic technology

Robotic assistance in hip prosthetic surgery has steadily increased in recent years, as it enhances the surgeon's precision and accuracy in component placement.

Since 1994, more than 17000 THAs have been performed with the Robodoc Surgical Assistant System (Sacramento, CA, United States), with controversial results.

Although Bargar *et al*[69] demonstrated better stem positioning and leg length equality compared to manual surgery, a significantly higher dislocation rate was found using Robodoc (18% *vs* 4%) in a prospective study, and the difference was associated with intraoperative muscle damage caused by the robotic milling system[70].

Using the MAKO robotic-arm-assisted system (Stryker Ltd., Kalamazoo, MI, United States), which is based on preoperative computed tomography, Illgen *et al*[71] observed a 71% improvement in accuracy and a significantly lower dislocation rate (0% *vs* 3%) compared with manual THAs at least 2 years after surgery. A cadaveric investigation showed a greater accuracy than manual placement for cup orientation and acetabular tilt, with 95% of prostheses implanted within 5° of the planned patient-specific values before surgery[72].

In a meta-analysis and systematic review performed by Chen *et al*[73] in 2018 involving 522 robotic-arm and 994 conventional THAs, better cup and stem placement, and global offset occurred in the first cohort.

As the learning curve associated with robotic assisted THA is minimal and immediate improvement in the accuracy of acetabular component position can be achieved[74], it can be of considerable support especially for patients at higher risk of postoperative instability, such as those with reduced spinopelvic mobility.

Using a simple algorithm based on a trigonometric mathematical model to determine the dynamic 3-D reorientation of the acetabular component during functional sagittal PT, Snijders *et al*[75] demonstrated that the effect of functional PT is specific to the initial cup orientation and thus per THA patient.

DISCUSSION

THA is one of the most successful and cost-effective orthopedic surgeries, as it provides pain relief and functional improvement, thus enhancing patients' quality of life. Although advances in technology, implant design, and surgical technique have dramatically reduced the dislocation rate in primary THA, it remains a major problem in reconstructive joint surgery. National joint registries and meta-analyses report dislocation as one of the most common causes of prosthesis failure[76]. In a large epidemiological study in the United States, dislocation was the main indication for revision, accounting for 22.5% of the procedures[77]. Economic consequences associated with dislocation must not be underestimated, including repeated hospitalizations and substantial financial burden to both the patient and the healthcare system. Closed reduction and revision surgery were found to increase costs for patients by 19% and 148%, respectively[78].

The etiology of dislocation after primary THA is multifactorial, depending on patient characteristics and surgical aspects[79].

Advanced age (> 70 years), female sex, obesity (BMI > 30 kg/m^2), a high ASA score (3-4), and neuromuscular and cognitive disorders are well-known conditions that predispose to dislocation[80]. Moreover, an increased risk is documented in joint disorders as avascular necrosis of the femoral neck, inflammatory arthritis, neck fractures, and in patients who previously undergone hip surgery[3],

While it is strongly recommended that the operation is performed by a skilled surgeon who performs at least 35 THAs per year[31,33], the role of the surgical approach in affecting the risk of dislocation is still controversial[35]. Recent advancements in minimally invasive surgery for THA and appropriate reconstructive procedures (capsular repair) have gained widespread popularity and helped to reduce this complication[81].

A current and interesting issue is the strong correlation between the degree of vertebral rigidity as a result of a degenerative disease or postoperative fusion and the increased risk of dislocation. Lumbar pathology may prevent normal dynamic motion leading to spinopelvic stiffness and abnormal pelvic position. Consequently, the mobility of the lumbar spine and relative x-ray (both in standing and sitting position) should be carefully assessed prior to surgery to identify an altered PT that could suggest different cup positioning. According to these findings, the acetabular component orientation should be evaluated by considering the functional rather than the static position of the pelvis[82], and the recurrence of dislocation needs to rule out spinopelvic changes as a potential cause of failure[83].

In a meta-analysis and systematic review performed by Onggo *et al*[84] in 2021, comparable dislocation and revision rates were found between patients undergoing THA with subsequent or prior lumbar arthrodesis. However, in another recent study, patients with concomitant hip and spine pathology were likely to benefit from hip replacement first before vertebral surgery to minimize the risk of instability[85].

Nevertheless, another systematic review and meta-analysis demonstrated a significant superiority in various assessed outcomes for patients who underwent THA without prior lumbar arthrodesis, including a lower incidence of dislocation [86].

Finally, patients with pathologic spinopelvic motion should be given special advice regarding the risk of dislocation.

Undoubtedly, the correct positioning of the cup plays a crucial role in the stability of a primary THA. However, the historical Lewinnek safe zone[43], which had been considered the optimal acetabular position for decades, has been shown to be inadequate, and the ideal orientation of the socket seems to be patient-specific[87-89]. In a clinical and radiographic study, Grosso *et al*[90] showed that in a dislocating cohort, a decreased percentage of cups were within the safe zone, and an increased cup anteversion alone may not prevent posterior instability in patients with abnormal spinopelvic characteristics.

Navigation technology and robotic-assisted surgery more reproducibly achieve intraoperative component positioning, which has clinical benefits with reduced risk of dislocation[91].

Several surgical options, including DM constructs, constrained liners, large diameter femoral heads, and modular neck stems, are currently available for the management of primary THA dislocation.

In a randomized controlled trial, larger femoral heads (≥ 36 mm) have shown a lower incidence of dislocation in primary THA because of the increased jump distance and head-neck ratio[63,92,93].

DM acetabular components, which were introduced in France in 1974, combine Charnley's low friction principle with the Mckee-Farrar concept of using larger diameter femoral heads to enhance stability after THA[94-96]. A recent systematic review and network meta-analysis performed by Pituckanotai *et al*[76] found a significantly lower risk of revision and dislocation of DM implants compared to standard single mobility THA, while there was no statistically significant difference between DM cups, large femoral heads and constrained liners. Therefore, DM components are an effective and safe choice in preventing this complication, as supported by long-term case series[59,97,98] and a systematic review of comparative studies[99].

Conversely, the use of constrained liners should not be considered in primary and elective THA and must be currently limited to revision surgery, as it is associated with a higher rate of mechanical failure[100].

Femoral stems with exchangeable necks were designed to optimize joint biomechanics during THA, providing a more accurate adjustment of the version, offset and leg length independently from stem size or position[101]. Although a few comparative papers[102] and registry data[103] showed an increased mean revision rate for dislocation in nonmodular stems, the difference was not statistically significant. Additionally, a higher incidence of revision than fixed-neck implants was reported by two large national joint registry studies[68,104]. The theoretical advantages of a more precise restoration of native anatomy and the efficacy of modular neck prostheses in reducing dislocation risk have not been confirmed yet, especially with the posterior approach[68,104]. However, modularity in the neck-stem junction was found to be particularly useful to simplify surgery in severely deformed femur and in cases of dysplasia[105], suggesting that modular implants may potentially have a role in patients with significant anatomical variation.

The most important limitation of this review is the low level of evidence of the available studies, mostly performed using a retrospective design. Although selection and recall bias cannot be completely excluded, most of them include comparative case series.

However, the results of this analysis should help the surgeons performing THA to strive to investigate the implications on outcomes of the dynamic interplay between the spine, pelvis, and hip. In these higher-risk cohorts, all options must be considered in order to prevent or minimize the incidence of dislocation, and DM cups are likely to be the most effective choice.

CONCLUSION

The overall dislocation rate after THA is relatively low, but specific predisposing factors may substantially increase this risk. Consequently, special attention should be paid to patients with a history of neuromuscular and cognitive disorders, prior hip procedures or trauma, or spinal deformities and surgeries.

FOOTNOTES

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Country of origin: Italy

ORCID number: Dario Regis 0000-0003-4557-9207.

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