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Etiology, Evaluation, and Management of Dislocation After Primary Total Hip Arthroplasty

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Abstract

» The rate of dislocation after primary total hip arthroplasty has decreased, but given the high volume of total hip arthroplasty procedures that are performed, dislocation remains a common complication.

» The etiology of dislocation after total hip arthroplasty is multifactorial and depends on the patient's characteristics as well as the orthopaedic surgeon's operative techniques and decisions regarding implants.

» A detailed assessment of the patient, preoperative planning, a thorough understanding of the anatomy, proper surgical technique, and knowledge of the biomechanics of the implant decrease the likelihood of dislocations following total hip arthroplasty.

» The advent of new techniques and procedures has further reduced the occurrence of dislocation following total hip arthroplasty. However, should dislocation occur, primary management or revision total hip arthroplasty techniques provide excellent results to salvage the mobility and function of the hip.

With nearly 400,000 Americans undergoing total hip arthroplasty every year, total hip arthroplasty deserves the distinction of "operation of the century"[1,2]. Although the surgery drastically decreases pain, improves function, and increases quality of life, total hip arthroplasty is not without risk and failures. The most common reason for failure and indication for early revision is instability[3]. The rate of dislocation after primary total hip arthroplasty ranges from 0.2% to 10% and is as high as 28% with revision total hip arthroplasty, affecting thousands of patients per year[3-6]. Therefore, dislocation represents a major challenge to the orthopaedic surgeon and the health-care system. This article reviews patient risk factors, surgical techniques, implant design, and management strategies regarding total hip arthroplasty instability.

Risk Factors

Timing

Dislocation is the most common early complication of total hip arthroplasty following primary implantation, and most dislocations occur within 3 weeks of the index procedure[7]. Of note, the timing of a first dislocation is a risk factor for having a second dislocation. Brennan et al. demonstrated that patients with a first-time dislocation at 13 weeks had an increased risk of occurrence of a second dislocation when compared with those who had a first-time dislocation at 3 weeks[8]. Therefore, early dislocation may be an indicator of instability due to surgical technique, including inadequate soft-tissue tensioning or lack of repair of the surgical approach, or patient noncompliance since even well-positioned implants will dislocate under these circumstances. In contrast, late first-time dislocations

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may indicate poor implant orientation because normal biomechanics are disrupted and, therefore, physiologic loading over time will cause alterations of the joint, leading to instability, possible eccentric wear, and dislocation.

Patient Factors

Patient-related factors are major determinants of instability following total hip arthroplasty. Past investigations have reported that neuromuscular and cognitive disorders, including dementia, Parkinson disease, and cerebral palsy, increase the likelihood of dislocation[3,9]. An analysis of the Nationwide Readmissions Database for elective primary total hip arthroplasty between 2012 and 2014 demonstrated increased odds ratios (ORs) of 1.63 (95% confidence interval [CI], 1.05 to 2.51, $p = 0.03$) and 1.96 (95% CI, 1.13 to 3.39, $p = 0.02$) for dislocations in patients with Parkinson disease and dementia, respectively[10]. However, other studies have not found similar associations. Based on data from the Scottish National Arthroplasty Project, Meek et al. reported no association between Parkinson disease and risk of dislocation, and they cautioned surgeons against prejudice when considering total hip arthroplasty in patients who had been diagnosed with Parkinson disease[9]. Moreover, a recent cohort study reported no difference in rate of complication, particularly dislocation, after hip arthroplasty for osteoarthritis in patients with cerebral palsy[11]. However, an analysis of the National Joint Registry for England, Wales, and Northern Ireland reported elevated patient-time incidence rates (i.e., numbers of revisions divided by the total time at risk for all patients) of dislocation and/or subluxation in patients with cerebral palsy when compared with controls[12]. This lack of consensus on the association of neuromuscular disorders with hip stability following total hip arthroplasty indicates the need for additional study.

Cognitive dysfunction from aging, psychiatric diseases, and alcoholism also is a risk factor for dislocation[9,13]. A retrospective review of data from 6 Danish arthroplasty departments reported that patients who are ≥75 years old and those who are being treated pharmacologically for a psychiatric disease may have a predisposition for increased risk of complications after total hip arthroplasty (OR, 1.96 [95% CI, 1.18 to 3.38] and 2.37 [95% CI, 1.29 to 4.36], respectively), but causality of this association remains unstudied[14,15]. Excessive alcohol use (defined as >72 ounces of beer or >6 ounces of other alcoholic beverages daily) is also implicated as a risk factor for increased risk of dislocation after total hip arthroplasty[16].

Lack of patient education and compliance with hip precautions during the postoperative period increases the risk of dislocation[3,17]. A prospective cohort study comparing patients who had preoperative education to patients who had no preoperative education found that the educated patients had a 1.3% absolute risk reduction of dislocation following total hip arthroplasty[17]. Patient compliance also is key to avoiding hip positions that can cause dislocation, and decreased compliance has been shown to increase the risk of dislocation after total hip arthroplasty[3].

Previous Surgeries

Additional factors to consider include prior hip fractures or surgical procedures. Many patients, especially active geriatric patients, with prior trauma and fractures are treated with total hip arthroplasty rather than open reduction and internal fixation. The effect that prior trauma to the femoral neck and/or head with resulting fractures has on the stability of the primary total hip arthroplasty and the dislocation rate remains controversial. A study from 2003 found no association between prior fracture and rate of dislocation after total hip arthroplasty[18], but a more recent, 2006 registry study did indeed demonstrate an increased risk of dislocation following a total hip arthroplasty that was used to treat a femoral neck fracture[9]. However, patients who undergo total hip arthroplasty for osteonecrosis of the femoral head do not have increased dislocation rates[19]. Previous revision total hip arthroplasty surgeries are associated with dislocation rates up to 28%[3]. This high occurrence of dislocation after revision total hip arthroplasty is thought to be attributed to substantial soft-tissue trauma and trochanteric nonunion[20].

Spinopelvic Alignment

Recently, the topic of spinopelvic motion has been gaining noteworthy attention because many patients have pathology that affects the hips and the spine. Patients with spinal arthrodeses (fusions), degeneration, or deformities have a considerably higher rate of dislocation than age and sex-matched patients without these issues[21,22]. A database analysis of patients who have undergone spinal arthrodesis prior to total hip arthroplasty demonstrated higher dislocation rates, which increased with more levels of spinal fusion[22]. Compared with a dislocation rate in the control group (patients who had not undergone fusion) of 1.55%, the dislocation rate for patients with spinal fusion of 1 to 2 levels was 2.96% (OR, 1.93; 95% CI, 1.42 to 2.32; $p < 0.0001$), and it was 4.12% (OR, 2.77; 95% CI, 2.04 to 4.80; $p < 0.001$) for patients with spinal fusion of 3 to 7 levels[22]. Sing et al. reported a similar correlation of increased dislocations with an increased number of fused vertebrae[23]. They reported that 4.26% of patients with 1 to 2 levels of fusion experienced dislocation compared with 7.51% of patients with ≥3 levels of fusion[23]. Perfetti et al. further asserted that at 12 months, patients who had undergone spinal fusion and total hip arthroplasty are 7.19 times more likely to have a dislocation and are 4.64 times more likely to undergo revision compared with patients without any spinal fusion who undergo total hip arthroplasty[21]. Other recent investigations on the effects of spinal pathology reinforce the theory that patients with sagittal spinal deformity have a particularly high rate of dislocation after total hip arthroplasty, with a revision rate of 5.8% to 8.0% for instability[24].

Spinopelvic imbalance results in a change of the functional position of the acetabulum, creating the potential for dislocation[25]. This is emphasized because most of these dislocations occur when the acetabulum is within the Lewinnek safe zone[26]. This functional position of the acetabulum is determined by the coordinated motion of the spine, the pelvis, and the hip[27]. With standing, the pelvis is tilted anteriorly, the lumbar spine has a lordotic curve, and the acetabulum is relatively closed over the femoral head. When sitting, the lumbar spine straightens, the pelvis tilts posteriorly, and the acetabulum opens anteriorly. If the lumbosacral junction or the hips becomes stiff, compensatory increased motion in the other component occurs. In the setting of a fused or degenerative spine, this results in increased hip movement that can lead to instability after total hip arthroplasty. A recent study determined that for every 1° loss of pelvic motion, there is an increased 0.9° of femoral motion, which correlates with loss of spinopelvic motion and compensatory increased hip motion[27]. A method to evaluate this spinopelvic imbalance is to obtain sitting, standing, and stair-climbing radiographs so that the functional position of the acetabulum can be determined.

The overall rate of dislocation after total hip arthroplasty may be low, but certain risk factors exist that can substantially increase the risk of dislocation. Special consideration should be given to patients with a history of neuromuscular and cognitive disorders, prior hip surgeries or trauma, or a history of spinal deformities and procedures (Table I). Although many of these risk factors are out of the surgeon's control, detailing the patient's history and risk factors will allow the arthroplasty surgeon to consider interdisciplinary communication with the patient's other health-care providers, evaluate optimal surgical techniques, and determine alternative options in order to provide the best treatment for the patient.

TABLE I Patient Risk Factors for Dislocation

Patient Risk Factor	Description
Timing	Late dislocation (≥13 weeks) increases risk of second dislocation
Patient factors	Neurologic issues: dementia, cerebral palsy, Parkinson disease, cognitive dysfunction; lack of preoperative education
Previous operations	Prior hip fracture, revision total hip arthroplasty
Spinopelvic alignment	Spinal fusion, spinal deformity

Evaluation of Dislocation After Total Hip Arthroplasty

History and Physical Examination

When a patient arrives with a dislocated hip, a thorough history and physical examination are required. Most patients will report a "clunk" or "popping" sound that was followed by pain[28,29]. It is important to determine the sequence of activities that led to the dislocation and whether the event is a first-time or recurrent dislocation[3,30]. Dislocation that is precipitated by everyday controlled movements as opposed to trauma may be suggestive of component malpositioning or inadequate tissue tension[3]. A review of previous documentation regarding the hip joint such as operative notes on approach type, implant components, and position also should be performed[3,30]. On physical examination, the affected leg with a posterior dislocation will show ipsilateral shortening and/or hip flexion, adduction, and internal rotation[3,30]. With an anterior hip dislocation, the ipsilateral leg will likely demonstrate flexion, abduction, and external rotation. The examination should include both lower extremities, with careful assessment of the pelvis and the knee, gait (if possible), range of motion, and strength[30].

Imaging

After the history and physical examination, it is important to obtain static and dynamic radiographic assessment of the dislocated hip. Initial radiographs should include an anteroposterior pelvic view, along with an orthogonal (e.g., cross-table lateral) view to assess for dislocation direction, implant loosening, or periprosthetic fracture[3,29]. Important landmarks on radiographs include an approximation of the center of the femoral head, violation of the Shenton line, and the presence of a lesser trochanter shadow (i.e., less exposure of the lesser trochanter, which suggests internal rotation)[29]. The horizontal-beam lateral hip (shoot through hip) radiograph can be useful for evaluating version, but advanced imaging with computed tomography (CT) of the hip may be necessary depending on the presentation. CT is more sensitive to malpositioning, loosening, or associated fractures surrounding the implant and can identify the direction of dislocation[3,29]. Magnetic resonance imaging (MRI) evaluation of hip dislocation is controversial and should not be employed routinely[29,31]. However, in cases of suspected abductor avulsion, adverse local tissue reaction, or dehiscence of the short external rotators, MRI evaluation may be beneficial[31].

Dislocation Classifications

After the initial evaluation, identifying the etiology of the dislocation can help to guide the surgeon toward the appropriate treatment. There have been many classifications suggested over the decades; however, they all have similar characteristic groupings[32-34]. Wera et al. reported on 75 revisions that had been performed for dislocation, and they determined 6 classification types: type I, acetabular component malposition; type II, femoral component malposition; type III, abductor deficiency; type IV, impingement; type V, late wear; and type VI, unresolved etiology[32]. As mentioned above, spinopelvic imbalance has been recognized as an etiology of dislocations and may be included in other iterations of classification. Understanding and categorizing the etiology can help to address the specific treatment that is required to recreate a stable hip (Table II).

Management

Nonoperative and Operative Treatment

Typically, nonoperative treatment consisting of closed reduction should be considered first and is indicated with a first-time dislocation without fracture or signs of underlying instability (Fig. 1)[3,30]. However, in cases of fractures, underlying component malpositioning, and/or recurrent dislocations, surgical revision is typically indicated[3,30]. Revision arthroplasty requires a more extensive preoperative assessment than primary total hip arthroplasty. It is crucial to determine whether the acetabular, femoral, or both components need to be revised; the possibility of an adverse reaction to implant material or debris as well as the status of the implants regarding wear and orientation also must be considered.

In revised total hip arthroplasties, there is no significant difference between rates of dislocation among solely femoral, solely acetabular, or combined femoral and acetabular revisions, with dislocation rates of 7.1%, 9.0%, and 7.3%, respectively ($p = 0.61$)[20]. Elevated-rim liners reduce the risk of dislocation with both primary and revised total hip arthroplasties[20,30]. As demonstrated by Alberton et al., an elevated-rim liner decreased the risk of dislocation by 2.2 times in acetabular revision alone and by 4 times in combined femoral and acetabular revision[20]. They suggested that the exchange of the femoral component requires additional exposure and may cause further muscle weakness, leading to a higher likelihood of dislocation without an elevated-rim liner.

For most cases of first-time hip dislocations without underlying pathology, initial treatment involves closed reduction with careful attention to the direction of the dislocation because anterior and posterior relocations require distinct maneuvers[35]. Ideally, the reduction is guided by fluoroscopy with the patient under procedural sedation in the emergency department (ED) or general anesthesia in the operating room[35,36]. With procedural sedation, propofol should be the first-line agent because of its lower complication rate and faster recovery time than other commonly used sedations in the ED, such as etomidate and opiate/benzodiazepines[37]. Furthermore, propofol allows for a deeper sedation with greater muscle relaxation, which facilitates a higher success rate for the reduction.

After a successful closed reduction, some studies recommend avoiding weight-bearing for 24 hours[35]. The patient is advised to increase hip mobility gradually under the guidance of a physiotherapist and to avoid dangerous positions for 3 months[35]. Additionally, patients receive recommendations to use an abduction pillow, brace, or knee immobilizer[38]. However, the utility of bracing has been questioned because some studies have demonstrated that 69% of patients who used bracing had

TABLE II Revised Dislocation Classification*

Type	Etiology	Diagnosis	Treatment
I	Acetabular component malposition	Anteroposterior pelvic radiograph: calculate acetabular version by arcsin(1)[26]; pelvic CT: calculate version	Revision of the acetabular component
II	Femoral component malposition	Pelvic and knee CT performed in same sequence: measure version	Revision of the femoral component
III	Abductor insufficiency	MARS-MRI: evaluate abductor soft tissue; gait test: evaluate for Trendelenburg limp	Constrained liner; some authors have had success with dual mobility components
IV	Impingement	Intraoperative detection: evaluate for subtle signs of wear on the femoral neck and acetabular metal rim; when performing a full range of motion, check for impingement in all degrees of motion	Remove offending impingement structures
V	Late wear	Anteroposterior pelvic radiograph: migration of the femoral head superiorly and laterally	Liner exchange; curettage and bone-grafting of the osteolysis for contained defects
VI	Unknown etiology	Unable to be determined based on plain radiographs and advanced imaging	Constrained liner
VII	Spinopelvic imbalance	Sitting and standing lateral radiographs: evaluate sacral tilt; determine pelvic motion as normal, hypermobile or stiff; and then evaluate cup position and determine anteversion and inclination	Anteversion and inclination of the cup varies based on the position of the acetabular component[78]

*CT = computed tomography, and MARS-MRI = metal artifact reduction sequence magnetic resonance imaging.

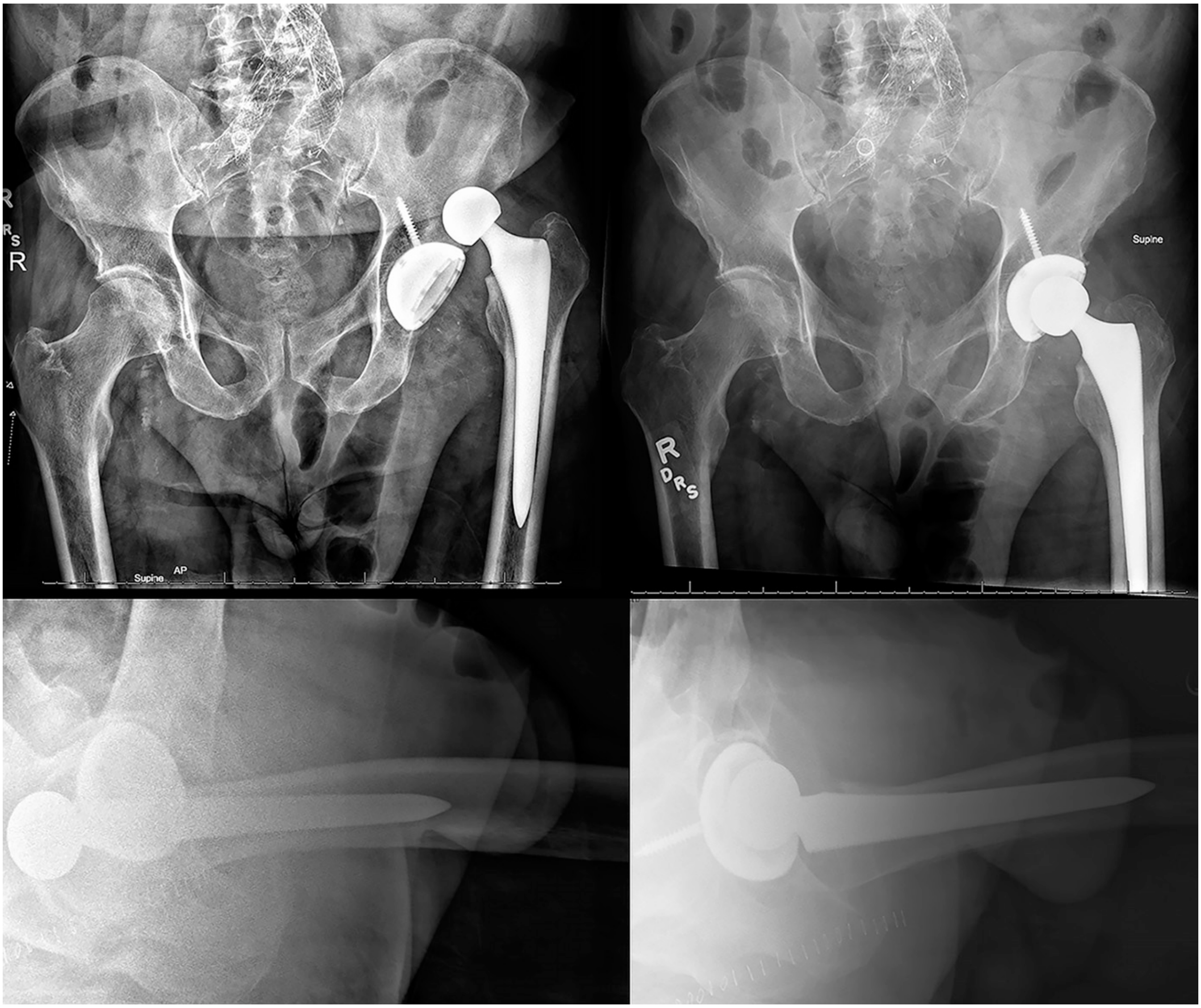

Fig. 1

Anteroposterior (top) and lateral (bottom) radiographs of a 79-year-old man with a dislocation after a primary total hip arthroplasty (left, top and bottom), which was treated successfully with closed reduction (right, top and bottom).

the same dislocation rate as those who did not use bracing[38]. Furthermore, abduction bracing can be associated with patient discomfort such as sleep disturbance and skin irritation. Despite common recommendations for patients to use these immobilization methods after reduction of a dislocated hip, there is limited evidence to support their use[38-40].

While most first-time dislocations may be managed nonoperatively, closed reduction is not always successful[41]. In a retrospective review of 1,250 hips with total hip arthroplasties that had been performed through posterolateral approaches with posterior soft-tissue repair, recurrent dislocations occurred in 1.6% of hips[41]. In those cases, surgical intervention frequently was required to address the underlying cause[41-43]. First-line revision options usually consist of correction of malpositioned components, tensioning or augmentation of soft tissues, improving the head-to-neck ratio, or revision of worn or damaged implants[42].

Surgical decisions along with accompanying techniques greatly affect the overall stability of the implant. Several surgical considerations influence the likelihood of dislocation following total hip arthroplasty. The incidence of postsurgical dislocation varies according to the type of approach, soft-tissue tension, femoral offset, head size, component positioning, acetabular liner profile, impingement, and surgeon experience.

Surgical Approach

The posterior approach for total hip arthroplasty has remained popular in the contemporary period. However, in recent years, great interest has been directed toward anterior approaches because of the increasing evidence that patients who undergo anterior approaches have shorter hospital stays, less perioperative pain, and faster functional recovery without compromising hip stability when compared with other approaches[44,45]. Although short-term outcomes and complication data at 90 days postoperatively reveal no difference in dislocation rate between patients undergoing anterior or posterior approaches, there have been data from a small set of studies that favor the anterior approach. Direct anterior approaches and anterolateral approaches are purported to lower dislocation risk without increasing the risk of early revision with an adjusted hazard ratio (HR) of 0.44 (95% CI, 0.22 to 0.87) and 0.29 (95% CI, 0.13 to 0.63), respectively, relative to the posterior approach for a follow-up period of 2 years[46]. Moreover, a 30-year study of 21,047 primary total hip arthroplasties demonstrated that the 10-year cumulative risk of dislocation after posterolateral approaches was higher compared with anterolateral approaches, at 6.9% (95% CI, 5.9% to 7.8%) and 3.1% (95% CI, 2.6% to 3.5%), respectively[47]. Patients who have early dislocations after an anterolateral approach also report less recurrence than patients who have late dislocations after a posterior or transtrochanteric approach[8]. In contrast, recent data have demonstrated that there is no difference in dislocation rate regardless of approach[5]. The philosophy remains that the single major factor that minimizes the risk of dislocation is the appropriate positioning of implants and that the long-term risks of dislocation are generally comparable regardless of approach[48]. For revision total hip arthroplasty, limited data also suggest that approach does not play a role in dislocation[49].

Primarily Constrained Total Hip Arthroplasty

Patients considered to be at high risk for dislocation may be considered for primarily constrained total hip arthroplasty. Although this procedure is controversial and not well studied, 2 studies have investigated short-term results in patients with previously known high dislocation rates. Pace et al. reported on 154 primarily constrained total hip arthroplasties for osteoarthritis in 137 patients with use of the Zimmer Natural Stem Longevity Constrained Liner and Epsilon Cup with 1 screw (Zimmer Biomet)[50]. They reported a 1.9% dislocation rate, a 2.6% infection rate, and a 0% component failure rate at 6 years[50]. It is important to note that the impetus for using the constrained liner primarily was the 9.8% dislocation rate that the authors had observed prior to use of the constrained liner[50]. Similarly, Gill et al. reported a 1.8% dislocation rate with 55 constrained liners in 54 patients with a short-term follow-up of 45-months[51]. A majority of the procedures were performed in patients with femoral neck fractures, with indications that included dementia, abductor insufficiency (fracture of the greater trochanter), or weakness and neuromuscular disorders. Longer term follow-up will be crucial to evaluate the longevity of constrained liners since many other studies report poorer results and increased failures in mid to long-term follow-up[52-54].

Soft-Tissue Tension and Repair

Soft-tissue tensioning via lengthening or shortening of the abductors and repair of the capsule is associated with a risk of dislocation. Surgical soft-tissue repair provides greater tension and additional stabilization of the total hip arthroplasty articulation[55]. The addition of soft-tissue repair via preservation and repair of the hip joint capsule reduces the likelihood of dislocation by one order of magnitude in the anterolateral, posterior, and posterolateral approaches[56]. Capsular repair of the posterior and posterolateral approaches is particularly important. In a meta-analysis of 7 clinical trials involving 45,594 hips, Zhang et al. reported lower dislocation rates and higher Harris hip scores with the posterior approach and the addition of soft-tissue repair[57]. In comparison to the lateral approach, soft-tissue repair in the posterior approach decreased dislocation risk by 3% in a prospective randomized trial with an average follow-up of 37.9 months[58]. Repair techniques in closing posterior soft tissues include a suture anchor, as described by Zhang et al.[59], and transosseous and transmuscular repair, as described by Spaans et al.[60].

Sufficient soft-tissue tension that is formed by the joint capsule, short external rotators, and gluteal muscles also is important in reducing dislocation rates following revision total hip arthroplasty[42]. Multiple studies have demonstrated reduced rates of dislocation with the addition of posterior soft-tissue repair in revision total hip arthroplasties[61]. Following revision total hip arthroplasties, 1.9% of hips that were revised through the posterior approach with soft-tissue repair dislocated compared with 10% of revised hips without soft-tissue repair[62]. Aota et al. detailed a novel soft-tissue reinforcement technique with a Leeds-Keio ligament during revision surgery, resulting in 82% of cases being resolved of their intractable dislocation[61]. Moreover, Dargel et al. reported that soft-tissue tension can be increased without extending the leg by increasing the offset between the femoral stem and the rotation center of the hip joint[3]. In a study of 79 hips, dislocation after posterior capsule repair in revision hip arthroplasty was 2.5% compared with ≥10% as described in other reports in the literature[18,63]. Also, rather than allowing the capsule to scar following revision surgery, capsulorrhaphy reduced dislocation rates from 2.8% to 0.6% in a study of 1,000 patients and from 4.8% to 0.7% in a study of 1,515 patients following primary total hip arthroplasty[42]. Trochanteric advancement is another method of augmenting the soft-tissue structures surrounding the joint; it stabilized the hips of 81% of patients who had an average of 3.9 dislocations following total hip arthroplasty[64]. Arthroscopically assisted capsular tightening also has been used in revision surgery to prevent additional dislocations. In a series of 20 patients from 2008 to 2013, 0 patients experienced additional dislocations after arthroscopically assisted capsular tightening[65].

Femoral offset has been determined to play a critical role in total hip arthroplasty stability. Normal offset of native hips ranges from 39 to 43 mm, and anatomic restoration can improve stability[26]. A recent study demonstrated that restoration of femoral offset was associated with decreased total hip arthroplasty instability[66]. Additionally, increased femoral offset results in an increased safe zone of motion following total hip arthroplasties with a posterior approach, with decreasing rates of dislocation[67]. However, a recent systematic review found no correlation between dislocation rates and femoral offset[68].

Implants

The improvements in jump distance and impingement-free range of motion with larger-diameter heads have reduced the incidence of dislocation[18,69]. Smaller-diameter femoral head sizes (22.2 mm) had a 2.4 times higher risk for dislocation in a prospective multicenter study[70]. Multivariate analysis reported that the relative risk of dislocation was 1.7 times for 22-mm heads compared with 32-mm heads, and 1.3 times for 28-mm heads compared with 32-mm heads[71]. The use of 22-mm femoral heads resulted in a higher relative risk of 2.0 (95% CI, 1.2 to 3.3) of revision due to dislocation than the use of 28-mm heads[72]. A larger, 36-mm articulation also significantly decreased the incidence of dislocation by 3.6% (95% CI, 0.9% to 6.8%) in the first year compared with the 28-mm femoral head[72]. However, 36-mm femoral heads had a higher rate of dislocation than anatomic femoral heads over a 10-year period, at 4.6% and 0.5%, respectively[73]. The advent of larger femoral heads has appeared to mitigate dislocation rates with all surgical approaches[54].

Component Malpositioning

Implant orientation affects dislocation risk greatly as initially described by Lewinnek, who determined that the safe zone for acetabular component placement consists of an abduction inclination of $40° \pm 10°$ and an anteversion of $15° \pm 10°$, which confers stability and decreases dislocation incidence[74]. Sanz-Reig et al. reported that malpositioning of the acetabular component in relation to the safe zone (acetabular abduction $>50°$ and anteversion $<10°$ or $>20°$) is a risk factor for dislocation[75]. However, recent studies have suggested that the Lewinnek safe zone may not be applicable, especially in cases of abnormal anteversion or abnormal dynamic pelvic motion (e.g., in patients with dysplastic hips, ankylosing spondylitis, or spinal deformities)[24,76,77]. Combined anteversion (i.e., the sum of the anteversion of the acetabulum and the femur) is a technique that positions the cup on the basis of the femoral anteversion. A combined anteversion between 25° and 50° has been shown to reduce the dislocation rate after primary cementless total hip arthroplasty compared with a combined anteversion outside that zone, which led to a 6.4-times more likely risk of dislocation[76]. Patients undergoing total hip arthroplasty with concomitant spinal deformity have a particularly high rate (8%) of dislocation despite having acetabular cups that are positioned in the safe zone[24,78]. Seagrave et al. reported that systematic review of the Lewinnek safe zone leads to inconclusive results of its benefits because of the high variability between studies, the lack of standardized cup-positioning measurements, and the multifactorial nature of dislocation after total hip arthroplasty[79]. Furthermore, restoration of the native anatomy plays a crucial role in preventing instability after total hip arthroplasty. Femoral offset, acetabular offset, combined lateralization, and leg-length discrepancy must be considered[26]. The Lewinnek safe zone may provide some overall guidance; however, patient-specific zones of stability based on static and dynamic states, soft-tissue balancing, and osseous and muscular anatomy warrant additional research and surgical planning.

Large-Diameter Heads, Liner Options, and Dual Mobility Implants

Clinically, the use of large-diameter heads that led to a decreased risk of dislocation also resulted in use of thinner cup liners[80]. Elevated and constrained acetabular liners are used to increase the force that is required to dislocate the femoral head, thereby reducing the rate of dislocation[18,55] (Fig. 2). A comparative study of 896 total hip arthroplasties reported that 3.8% of hips with elevated-rim liners dislocated compared with 8.4% of non-elevated-rim liners[18]. Regarding constrained liners, in a retrospective review, Munro et al. suggested that an acetabular liner with focal constraint is associated with a relatively low risk of dislocation in high-risk patients[81]. However, constrained liners should be used with caution in cases of dislocation because they have a cumulative re-revision rate that is higher than more traditional implant designs, with rates as high as 16% to 29% compared with 1.8% with primary total hip arthroplasty since constrained liners cannot compensate for poorly positioned implants[51,82].

Another treatment option for recurrent dislocations is the use of bipolar femoral prostheses. Bipolar femoral prostheses are theorized to increase hip stability by increasing the head-to-neck ratio, the range of motion, and the jump distance[42]. In a review of 27 patients with recurrent instability, bipolar arthroplasty prevented additional dislocations in 81% of patients[83]. However, bipolar hip arthroplasty should be considered only when other stabilization attempts have failed because of a high volume of reported symptoms of continued hip pain and muscle weakness, as well as the need to use walking aids[42,83].

Clinically, dual mobility implants are another important revision option because they reduce the risk of dislocation after revision arthroplasty in patients with chronic instability[84]. A review of 64 revisions demonstrated a 98% 3-year survival rate of the implant, with only 2 dislocations at 38 months of

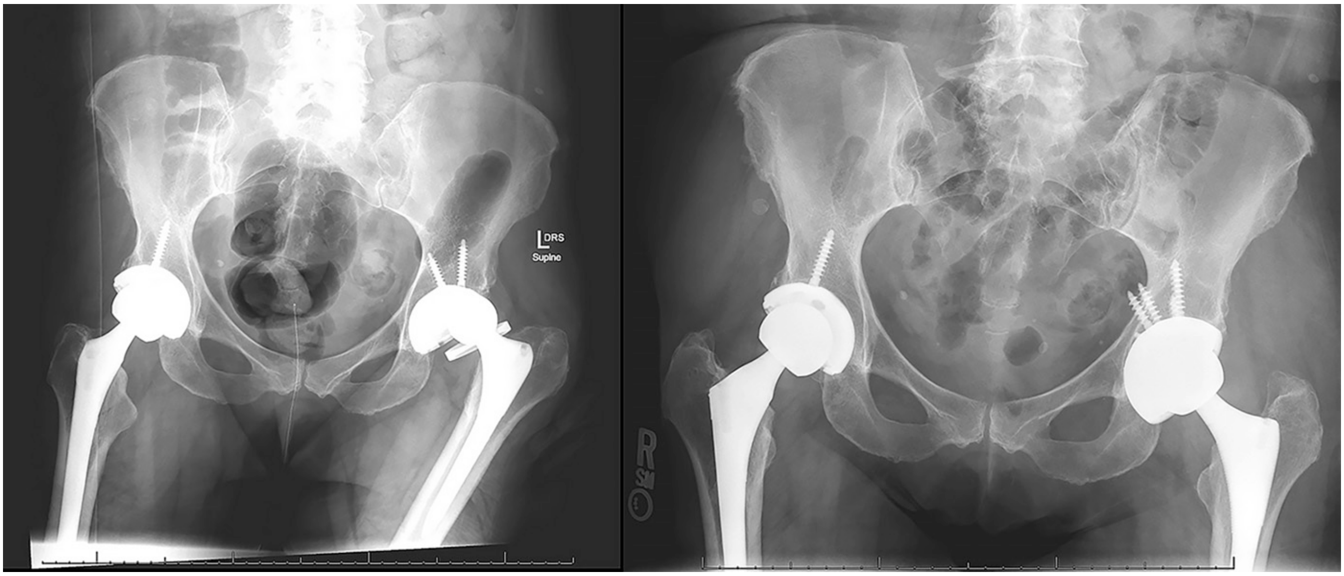

Fig. 2

Anteroposterior radiographs of a 67-year-old woman who had undergone a prior revision total hip arthroplasty with a constrained liner because of repeat dislocations. She continued to have instability and dislocation with the constrained liner (left) and, eventually, the acetabular component was revised (right).

follow-up[84]. Larger studies, such as the multicenter analysis by the French Society of Orthopaedic Surgery and Traumatology of 3,473 hips, had even lower rates of dislocations (0.43%) in long-term follow-up of 5 to 11 years[70]. Furthermore, van Heumen et al. reported that dual mobility cups, which have an excellent 5-year survival rate with no radiographic evidence of osteolysis, are an effective solution for recurrent hip dislocations[85].

Impingement

Impingement of the prosthetic femoral neck on the liner, the cement, or the osteophytes promotes dislocation of the femoral head from the acetabulum[42,69]. Interestingly, 80% to 94% of cups and liners that are used in patients who undergo revision for dislocation have impingement marks, compared with 51% to 56% of those who undergo reoperation for other reasons[86]. Miki et al. found prosthesis impingement to be a major risk factor for dislocation, which was most commonly due to component malpositioning[86]. Furthermore, larger femoral heads are believed to decrease dislocation because of their increased allowance of impingement-free range of motion[69,87]. Component positioning in patients with ankylosing spondylitis and spinal deformities, which are associated with decreased dislocation, is also attributed to preventing postoperative impingement[86,88].

Impingement may be decreased by increasing the femoral-head-to-neck ratio, which will delay the contact between the femoral neck and the liner, leading to increased range of motion and lower risk of dislocation[69,87]. Alberton et al. demonstrated that 28-mm and 32-mm heads reduced the risk of dislocation in patients with revised total hip arthroplasties compared with 22-mm heads[20]. Historically, heads >32 mm in diameter have led to increased volumetric wear of polyethylene liners and osteolysis surrounding the prosthesis. However, the development of cross-linked polyethylene liners and ceramics has demonstrated reduced wear and allowed for larger head sizes.

Surgeon Experience

All of the aforementioned factors that contribute to the dislocation risk following total hip arthroplasty must ultimately be considered by the surgeon. Surgical approach, technical skills, and component positioning rely on the knowledge and experience of the surgeon. Patients of less-experienced surgeons have an increased risk of dislocation after total hip arthroplasty compared with patients of their experienced colleagues[88,89]. Patients of surgeons who performed <5 total hip arthroplasties per year had a 50% higher rate of dislocation compared with patients of surgeons who performed ≥50 total hip arthroplasties per year[55,88]. Despite all of the factors that contribute to instability following arthoplasty, surgical decisions and techniques are most influenced by the surgeon; therefore, critical analysis and preoperative planning are essential for successful patient outcomes.

Girdlestone Procedure

The most invasive and typically final salvage option for patients with chronic hip instability is the Girdlestone procedure or resection arthroplasty. The Girdlestone procedure is a last resort for patients with multiple failed revisions who cannot undergo reconstruction with other procedures that are associated with morbidity, decreased function, and limb shortening[42,87]. Resection arthroplasty usually occurs in the setting of chronic infection and sepsis and, although somewhat disabling to the patient, does allow relative patient autonomy and mobility with walking aids[90,91]. Moreover, the Girdlestone procedure stabilizes the hip; however, conversion to a megaprosthesis has been reported because of patient dissatisfaction[90,91].

Overview

While the rate of dislocation after total hip arthroplasty is infrequent overall, with regard to total hip arthroplasty complications, dislocation is a challenging and common complication after primary and revision total hip arthroplasty. Therefore, there has been an advent of new techniques and procedures to further reduce the rate of dislocations. The etiology of dislocation after total hip arthroplasty is multifactorial and depends on both the patient's characteristics and the orthopaedic surgeon's operative techniques and decisions. Conducting a proper assessment of the patient, having an excellent understanding of the anatomy of the hip, performing preoperative templating, practicing good surgical techniques, and knowing the biomechanics of the implants are all factors that can help surgeons to decrease the likelihood of dislocations following total hip arthroplasty. However, if recurrent dislocations occur, revision total hip arthroplasty techniques do exist and can provide excellent results for salvaging the mobility and function of the hip.

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