TOPIC HIGHLIGHT

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Instability after total hip arthroplasty

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Abstract

Instability following total hip arthroplasty (THA) is an unfortunately frequent and serious problem that requires thorough evaluation and preoperative planning before surgical intervention. Prevention through optimal index surgery is of great importance, as the management of an unstable THA is challenging even for an experienced joints surgeon. However, even after well-planned surgery, a significant incidence of recurrent instability still exists. Non-operative management is often successful if the components are well-fixed and correctly positioned in the absence of neurocognitive disorders. If conservative management fails, surgical options include revision of malpositioned components; exchange of modular components such as the femoral head and acetabular liner; bipolar arthroplasty; tripolar arthroplasty; use of a larger femoral head; use of a constrained liner; soft tissue reinforcement and advancement of the greater trochanter.

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INTRODUCTION

Dislocation following total hip arthroplasty (THA) is a significant and unfortunately common complication. A landmark review in 1982 by Woo and Morrey of over 10 000 primary THAs reported a dislocation rate of 3.2%[1]. Other studies have reported dislocation rates of 0.3% to 10% for primary THAs and up to 28% for revision THAs[2-14]. The risk of dislocation is influenced by patient factors such as age, sex, previous surgery, and cognitive or neurologic disorders as well as surgical factors, including surgical approach, choice of implant, soft tissue and surgeon experience[13-15]. Although most dislocations after THA are isolated events and can be managed non-operatively, some patients will require surgical intervention to manage or prevent recurrent instability[7,16,17]. A thorough understanding of the etiology of dislocations, evaluation of an unstable THA, and appropriate management of such instability is necessary to ensure optimum outcomes for patients.

Instability is one of the most common complications of THA[1,7,16]. Determining the true incidence and prevalence of postoperative dislocation is challenging, as there are a variety of patient, surgical and implant factors, which compound the fact that most published reports on the topic are from high volume medical centers, which excludes community practices[14]. Most dislocations occur within the first 3 mo following surgery. The literature suggests that 50%-70% of dislocations occur within the first 5 wk to 3 mo postoperatively, and more than three fourths of dislocations within the first year follow-

ing surgery[1,8,9,17-19]. Accordingly, the cumulative risk of dislocation does not remain constant following THA, increasing with time due to trauma, polyethylene wear, increased pseudocapsule laxity and deteriorating muscle strength[20-22]. Improved understanding of the etiology of instability following THA and concordant improvements in surgical techniques have led to a documented decrease in the dislocation rate over time[23-27].

RISK FACTORS ASSOCIATED WITH DISLOCATION

Patient factors

Patient-related risk factors must be evaluated and considered preoperatively, intra-operatively and post-operatively although they are out of surgeon's direct control (Table 1). The independent correlation of height and weight with the risk of dislocation has not been clearly demonstrated in the literature[13,28]. Several other important patient risk factors for dislocation, however, have been identified. Two large series on gender differences report that women dislocate following THA approximately twice as frequently as do men[1,9,13,18,29,30]. This apparent gender disparity is postulated to be attributed to muscle mass and strength differences, as well as differences in the compliance and elasticity of the soft tissues as a result of genetic and hormonal differences between the sexes.

Evidence that age is an independent risk factor for dislocation is at best inconclusive and still controversial[13,28]. Larger series of patients have not found age to be an independent predictor of instability, yet reports do exist in the literature which find statistical trends or evidence to the contrary[14,31,32]. Advanced age (greater than 80 years old) brings increased frailty, decline in muscular tone, inability to follow postoperative protocols and higher incidences of cognitive problems, all of which have been linked to increased dislocation rates, and likely confound literature reports of age as an independent risk factor.

Patients with neuromuscular and cognitive disorders, including cerebral palsy, muscular dystrophies, psychoses, dementia and alcoholism have also been consistently demonstrated to be at a higher risk for postoperative dislocation[13,14,30,33-38]. Muscle weakness, muscle or general imbalance and inability to comply with with activity restrictions all are considered to be the likely causative factors[32]. Diseases such as muscular dystrophy and myasthenia gravis are inherent to the musculature and directly cause muscle weakness, which can increase dislocation incidence, particularly with abductor weakness. Other neurologic conditions, such as Parkinson's disease, cerebral palsy and multiple sclerosis can lead to similar muscle, particularly abductor, weakness. Cognitive dysfunction has likewise been shown to be an independent risk factor for hip instability following THA[32,39]. For these patients, noncompliance or inability to follow post-operative activity restrictions were implicated as the likely cause for dislocation.

Table 1 Risk factors for instability following total hip arthroplasty	
Patient factors	**Surgical factors**
Female gender	Surgical approach
Age > 80 yr	Capsular repair
Neuromuscular disorders	Soft tissue tension
Cognitive disorders	Component malpositioning
Alcoholism	Femoral head size
Abductor weakness	Impingement
Prior hip surgery	Surgeon experience

A history of prior hip surgery is also considered to be an independent risk factor for dislocation[14,17,36,38,40]. Woo and Morrey found the incidence of instability to double in hips that had undergone any previous open surgical procedure[1]. This is likely due to scarring, laxity and other soft tissue issues directly resulting from the previous operative procedure.

Patient-related risk factors, although out of the surgeon's control, are important to consider when evaluating a potential THA candidate preoperatively. Patients with one or more of these risk factors should be appropriately counseled preoperatively about their increased risk of postoperative instability.

Surgical factors

Several elements of the surgical process and technique may contribute to postoperative instability, including surgical approach, implant-related factors, soft tissue repair and tensioning, impingement and surgeon experience.

The incidence of instability as it relates to surgical approach has been extensively investigated and reviewed in the literature. Historically, higher dislocations rates have been reported for the posterior approach (5.8%) *vs* the anterolateral approach (2.3%)[1,36]. A recent meta-analysis involving 13 203 primary THAs found dislocation rates of 1.27% for trans-trochanteric, 3.23% for posterior (2.03% with capsular repair), 2.18% for anterolateral and 0.55% for the direct lateral approach[36,41]. Furthermore, the literature demonstrates that 75% to 90% of dislocations are in the posterior direction, thus surgical approaches that compromise posterior soft tissues theoretically could contribute to posterior instability[7,13]. Therefore, when risk of dislocation is of particular concern, the posterior approach historically has been the least favored. Other investigators have shown, however, that a meticulous posterior capsular repair decreases dislocation rates to comparable levels to other approaches. White *et al*[42] demonstrated a reduction from 2.8% to 0.6% in 1000 patients; Goldstein *et al*[43] reported a decrease from 4.8% to 0.7% in 1515 patients; and Pellicci *et al*[44] reported a reduction from 4.1% to 0.0% in 395 patients with posterior capsular repair[36].

Soft tissue tension, influenced by the joint capsule, short external rotators and gluteal muscles, has been meticulously evaluated as a factor in dislocation[13]. Even appropriately placed components may become unstable

if the appropriate length and offset are not restored. As discussed before, reconstruction of the posterior capsule and short external rotators after a posterior approach has been shown to significantly reduce dislocation rate[42-44]. The surgeon can also greatly affect soft tissue tension with femoral offset. Patients who dislocate have a notable loss of offset compared to patients with stable hips[33,35]. If the soft tissues are lax, and the offset has already been maximized, a lateralized liner can increase soft tissue tension.

Implant-related risk factors are also an important consideration, as malpositioning of components is the most common cause of instability[41]. Intrinsic implant related factors, such as implant type, design and size, are important to consider both preoperatively and intraoperatively. Femoral head component sizing is of particular interest. The larger the femoral head, the further it must sublux before it can dislocate, a distance referred to as the jump distance. Berry *et al*[29] in a study of 21 047 THAs, found a significantly decreased rate of dislocation with the use of larger femoral heads in all surgical approaches. Additional studies have also found decreased rates of dislocation with larger head sizes, although a large head has not always been found to be necessary to achieve low early dislocation rates[7,44,45]. When determining the appropriate head size, the surgeon must also consider the appropriate combination of socket type, orientation and approach to optimize the implant and minimize the dislocation rate. Increasing femoral offset has been described to have a positive effect on decreasing the incidence of dislocation by optimizing soft tissue tensioning[7,33,45]. Likewise, neck design and geometry have been demonstrated by numerous authors as important to the stability of the THA[46,47].

Component malposition is the most common cause of instability following THA[11,41,48]. Excessive anteversion of the acetabulum may result in anterior dislocation; excessive retroversion may result in posterior dislocation; similarly, excessive abduction may result in lateral dislocation. Ali Khan *et al*[18] found that the most common surgical error was placement of the acetabular component in excessive anteversion and abduction, a finding reinforced by numerous other authors[19,49]. A recent study by Callanan *et al*[50] found increased risk of acetabular cup malposition for minimally invasive approaches, low volume surgeons, and obese patients. Daly and Morrey[24] found that 86% of patients who underwent revision surgery without correction of acetabular component malposition continued to have instability. Furthermore, the largest number of successful revision surgeries occurred in patients who underwent repositioning of the acetabular component. Based on several studies, cup anteversion should be 20° ± 5° (measured from the axis of the cup) and 40° ± 10° of cup abduction to be considered in the safe zone of lower dislocation risk[13,51-53]. Forward rotation of the pelvis must be taken into account, or excessive retroversion of the cup can result[39]. Positioning of the femoral component is not as simple to evaluate due to lack of standardization regarding rotation. Many imaging modalities have been evaluated in an attempt to determine optimal femoral component orientation, but significance with regards to determining hip stability has not been definitely established[5,54].

Impingement, including prosthetic, cement or bony, is another surgical factor involved in dislocation. Whether caused by osteophytes that were not resected at the time of the primary surgical procedure, or capsular scar tissue or heterotopic ossification that developed postoperatively, impingement can directly be linked to instability, and should be addressed at the time of revision surgery. Daly and Morrey[7] found impingement as the primary cause of instability in 9 hips in a series of 95 recurrent dislocations. Surgical correction of this, however, had a success rate of only 56%.

Surgeon experience is the final surgical risk factor for THA instability. The rate of dislocation has an inverse relationship to the experience of the surgeon[55]. For every ten primary arthroplasties performed yearly, there is a 50% reduction in the postoperative dislocation rate[55]. There is also a high dislocation rate amongst surgeons who perform less than thirty THAs yearly[7].

EVALUATION OF UNSTABLE THA

The evaluation of an unstable THA should follow a standardized and methodical approach to allow formulation of the ideal treatment plan. Even with optimum component orientation, adequate soft-tissue balancing and the appropriate components, dislocation after THA can still occur in the hands of the most experienced joint surgeons.

History and physical examination
The history is vital to understanding how the dislocation occurred. Elucidating how the current dislocation occurred, or the activity that was being performed in relation to the position of the affected limb, as well as an inquiry into other potential previous episodes of instability or dislocation is of paramount importance. Questions regarding the presence of infectious symptoms such as fevers, chills, antecedent pain or night sweats are also important. A review of previous documentation, including operative notes documenting what approach was used, types and positioning of implants, as well as any noted intra- or post-operative complications is vital.

Physical examination should include assessment of both lower extremities, carefully noting gait, range of motion, strength (paying close attention to the abductor musculature), neurovascular status, leg length, location of previous incisions and leg position on presentation. Additionally, if clinically indicated, diagnostic tests including white blood cell count, erythrocyte sedimentation rate, C-reactive protein level, aspiration and cultures should be considered, as infection may be a contributing factor to the instability[13].

Radiographic evaluation
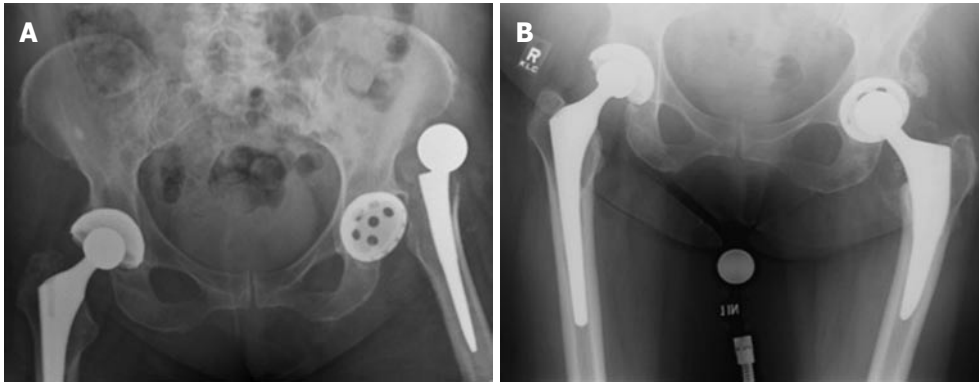Radiographic assessment begins with an anteroposterior

Figure 1 Anteroposterior pelvis radiograph of a 72-year-old female who sustained an anterior-superior dislocation of her left total hip arthroplasty approximately 1 mo after the index procedure (A) and the hip was reduced closed and found to be stable (B). Note the excessive anteversion of the acetabular component which is the likely etiology of the anterior dislocation.
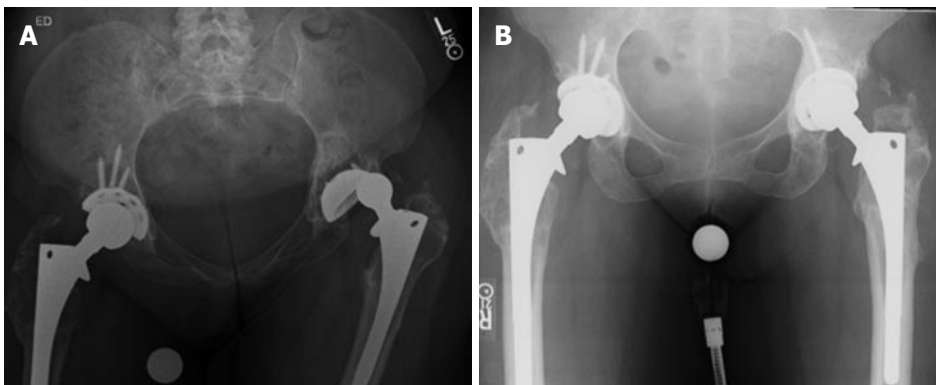

Figure 2 Anteroposterior pelvis radiograph of a 52-year-old female who is status post left total hip arthroplasty with subsequent revision of the femoral component for hardware loosening and instability. A: She sustained a prosthetic hip dislocation during physical therapy that was unable to be reduced by closed means. At the time of open reduction, revision total hip arthroplasty was indicated to correct the risk factors for instability; B: This included revision of the retroverted acetabular cup, revision of the malpositioned revision femoral stem, and increasing the femoral head size. The patient has not experienced any recurrent episodes of instability.
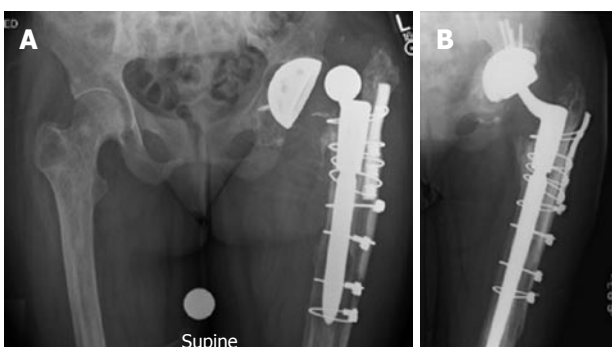

Figure 3 Anteroposterior pelvis radiograph of a 45-year-old female who is status post bilateral total hip arthroplasties, each of which had been revised once for osteolysis. A: She presented with recurrent dislocations of her left total hip arthroplasty and having failed conservative management; B: the patient underwent a second revision of her left total hip arthroplasty with acetabular component exchange and exchange to a large femoral head. Intraoperatively, her stem was found to be relatively neutral, which likely contributed to her posterior instability.

pelvis and true lateral radiograph of the affected hip (Figures 1-3). The femoral component should be assessed for head-to-neck ratio, loosening, neck length and offset, angulation and any evidence of subsidence. An attempt to determine the version of the femoral component should also be undertaken, although this can be challenging to measure radiographically. There is a high incidence of femoral malposition in hips with instability when femoral version is measured fluoroscopically[33]. Similarly, assessment of the acetabular orientation is difficult to ascertain from plain radiographs of the hip as well. Various methods have been described to measure acetabular anteversion using both plain radiographs and computed tomography scans[51,56].

TREATMENT OF THE UNSTABLE THA

The initial management of an unstable or dislocated THA is closed reduction. Once this has been completed, it is vital to assess the stable range of motion of the hip. Both non-operative and operative options exist, the choice of which depends on the patient's inherent risk factors for future dislocations, reason for the dislocation, acuity of dislocation, stable range of motion, treatment

goals and many other factors. It should be emphasized that instability is an extremely complex problem often better handled by an arthroplasty specialist[24].

Bracing

If the patient has instability or presents after a first dislocation, has an acceptable stable range of motion (> 90 degrees of flexion and at least 45 degrees of internal rotation), and post-reduction radiographs demonstrate acceptable alignment and position of components, then treatment with external bracing often results in good outcomes[19,53]. However, the use of braces is extremely patient-dependent, as the braces are inconvenient and cumbersome. Even the most compliant patients will have difficulty using braces effectively, making them challenging to study in large numbers or to implement effectively on a regular basis. Despite these challenges, it is estimated that two-thirds of patients can be successfully managed with closed reduction followed by bracing[57].

Surgical indications and management

In patients who have a secondary dislocation, who have failed conservative management, or obvious component malalignment is noted on plain radiographs, surgical revision should be a strong consideration. Of paramount importance is identifying the cause(s) of instability, and addressing all of the possible causes for the instability at the index revision operation[24]. Surgical options for the treatment of instability or recurrent dislocation include revision of components; exchange of modular components such as the femoral head and acetabular liner; bipolar arthroplasty; tripolar arthroplasty; use of a larger femoral head; use of a constrained liner; soft tissue reinforcement and advancement of the greater trochanter[16].

Preoperative considerations

The first consideration once surgical management of the unstable THA has been chosen is the surgical approach. Although convenient, the previous surgical approach need not always be used, especially if the revision surgeon is more familiar with a different approach. Whenever possible, however, previous incisions should be incorporated into the new approach, as parallel incisions may lead to vascular compromise of the bridging skin[58,59].

The more challenging preoperative decision in revision surgery is whether to retain well-fixed components. In general, when well-fixed components are malpositioned, they should be replaced[16,40]. Daly and Morrey[24] found that 6/7 patients with retained, well-fixed but malaligned components continued to have instability. In the case of infection, usually components will need to be exchanged following incision and debridement, in either a one or two stage procedure. When the components are well-positioned, retention with exchange of modular components is reasonable, although the revision surgeon must still be acutely aware that even subtle component malposition can result in clinically significant instability[40].

Modular component exchange

Modular component exchange is typically reserved for patients who do not have gross malpositioning of any components or significant abductor weakness[14]. This surgical treatment involves exchanging and elevating the polyethylene acetabular liner and upsizing the femoral head[16,60]. At the time of revision, the surgeon may take advantage of numerous modular options, including increasing femoral head size, increasing neck length, or various liner options. Several studies have demonstrated reasonable success (69%-96%) with modular component exchange[61-65].

Bipolar and tripolar arthroplasty

Bipolar and tripolar arthroplasty have also been successfully utilized in treating recurrent instability following THA[23,66-71]. The bipolar arthroplasty component consists of a small femoral head located inside a polyethylene shell that is then covered by a larger femoral head. This theoretically allows motion between the small femoral head and the liner as well as the larger femoral head and the acetabulum[16]. Placement of a bipolar prosthesis inside an acetabular component with a liner is known as a tripolar arthroplasty[16]. Parvizi *et al*[66] described the outcome of 27 patients who were treated for instability using this technique. In their study, 81% of patients gained hip stability, 7% experienced a single episode of instability, and the remaining 11% had recurrent instability requiring further surgery[14]. Nadaud *et al*[67] described a series of 23 revisions that were fixed cups switched to bipolar for instability. All patients in their series who underwent revision to a bipolar prosthesis had no further instability, leading them to conclude that acetabular revision to a bipolar prosthesis provides reliable stability in recurrent prosthetic hip instability.

Grigoris *et al*[72] first described the use of the the tripolar arthroplasty for the treatment of recurrent dislocation. In their series, 0/8 patients had recurrent dislocation at a mean of 4.2 years. Guyen *et al*[68] published a series of 167 primary THAs using tripolar arthroplasty at the index operation for patients with at least 2 risk factors for dislocation. At an average follow up of close to 2 years, no dislocations had been noted. Levine *et al*[71] reported a series of 31 hips revised with a tripolar articular construct for instability. 93% of the patients undergoing revision did not require further revision surgery.

There is clearly evidence in the literature supporting the use of bipolar and tripolar arthroplasty as salvage procedures in the management of recurrent dislocation. However, these do not come without problems, the most important of which is the potential for medial or superior migration of the prosthesis with time. Groin pain is also a frequently reported issue for these patients. Thus, the majority of authors do not recommend routine use of bipolar or tripolar arthropasty as main-stay treatment of recurrent dislocation[16,66,68,69].

Large femoral heads

Large femoral heads represent another option to address

hip instability. Femoral head sizes greater than 36 mm have been designed to provide increased stability through a rather simple theory: the larger the femoral head, the greater the volume of the head that needs to be displaced from the acetabulum for dislocation to occur. This is accomplished through an improved head-neck ratio and by increasing the jump distance (distance the femoral head must travel to dislocate)[9,73]. Kung *et al*[74] evaluated 230 patients for the effect of femoral head size (28 mm *vs* 36 mm) on postoperative stability. At a mean follow up of 27 mo, they found that the use of the larger femoral head brought the dislocation rate from 12.7% down to 0%. However, if the abductor mechanism was absent, there was no statistically significant reduction in dislocation rate. Smith *et al*[75] found similar success in 377 hips treated with 38 mm metal-on-metal arthroplasties, with no dislocations in the critical early follow-up period, however recent literature has questioned the use of metal-on-metal arthroplasties for other reasons. Peters *et al*[76] found similar success with the use of large femoral heads (38 mm), with a reduction of dislocation rate from 2.5% to 0%. Amstutz *et al*[77] investigated the use of large femoral heads for patients with recurrent dislocations (29 hips) and in primary surgeries (57 hips). The prevalence of dislocation was 13.7% for the recurrent dislocation group and 3.5 for the primary surgery group. The authors also noted that the use of large femoral heads necessitates simultaneous insertion of a thin polyethylene liner, the longevity of which has not been determined.

Constrained liners

Constrained liners are designed to physically resist dislocation of the femoral head by locking the head into the acetabular cup, and are an invaluable tool in the surgical management of recurrent dislocations[9]. This device is particularly useful for the surgical management of recurrent dislocation in the setting of abductor deficiency, recurrent dislocation of undetermined etiology and in patients with multiple dislocations due to neurological impairment[16]. The success of constrained liners for instability in these specific situations has been well-documented in the literature[4,5,12,78-81]. Additionally, constrained liners offer the ability provide enhanced stability to a hip without the need to revise well-fixed, well-positioned acetabular components[16]. Anderson *et al*[5] first reported the use of constrained liners as a salvage procedure in patients with recurrent dislocations. 71% of the 21 patients in their report experienced no further dislocations at a minimum of 2-year follow-up. Callaghan *et al*[25] reported a series of 31 hips with constrained liners implanted into well-fixed acetabular components, and found that 94% of patients were failure-free at an average follow up of nearly 4 years. Significant improvements in dislocation rates with the use of constrained liners in previously unstable THAs were also noted in more recent series[80,81]. Constrained liners offer a valuable option for the management of recurrent dislocations when no obvious cause for dislocation can be identified or if the dislocation is

due to soft-tissue deficit that is not otherwise repairable. The surgeon must, however, be careful to ensure that the components are well-positioned prior to proceeding with constrained liner placement, as even subtle component malpositioning can be the cause of such instability[16,40].

Soft tissue reinforcement

The use of additional static restraint to augment the deficient posterior capsule or enhance a deficient abductor mechanism have been described by many authors, although with notable variability in outcome. Lavigne *et al*[2] were the first to report the use of an Achilles tendon allograft placed between the greater trochanter and the ischium to reduce the range of internal rotation and enhance stability. In their series of 10 patients, 6 had complete elimination of instability at 3-year follow up. Recently Van Warmerdam *et al*[82] described the use of an Achilles autograft sling to improve hip stability. In their series of 8 patients, 7 patients had no recurrent instability with maintenance of good postoperative range of motion at an average of 5 years' follow-up. The authors concluded that allograft slings can be used to improve hip stability without significant limitation of postoperative hip range of motion.

Barbosa *et al*[27] described the successful use of a synthetic ligament prosthesis to treat 4 patients with recurrent posterior dislocation of THA without ascertainable cause. At an average follow-up of over 2 years, none of the patients experienced further dislocation. Stromsoe *et al*[83] described the use of fascia lata to augment deficient abductors. In their series of 18 patients with posterior THA dislocations, 16 achieved stability with the procedure.

Soft-tissue procedures provide an additional approach to achieving THA stability in patients who are poor candidates for other options such as constrained liners. These procedures can be technically demanding and are likely to fail in patients with any component malpositioning.

Greater trochanter advancement

Trochanteric advancement, although now somewhat historic, has been used to increase abductor tension and stability with good results[14]. The technique is designed and has been proven to improve the resting length and functioning of the abductor mechanism, which consequently affords increased hip stability in 81%-90% of cases[14,84-87]. The advent of modular implants allows the surgeon to increase femoral neck length to accomplish the same goals without the potential morbidity of greater trochanteric nonunion. Thus, it continues to be used only as an option when there is proximal migration of an ununited trochanter after a trochanteric osteotomy[14].

CONCLUSION

Instability following THA is an unfortunately frequent and serious problem that requires thorough evaluation and preoperative planning before surgical intervention.

Prevention through optimal index surgery is of great importance, as the management of an unstable THA is challenging even for an experienced joints surgeon. However, even after well-planned surgery, a significant incidence of recurrent instability still exists. Non-operative management is often successful if the components are well-fixed and correctly positioned in the absence of neurocognitive disorders. If conservative management fails, surgical options include revision of malpositioned components; exchange of modular components such as the femoral head and acetabular liner; bipolar arthroplasty; tripolar arthroplasty; use of a larger femoral head; use of a constrained liner; soft tissue reinforcement and advancement of the greater trochanter. In cases of recurrent instability after appropriate revision surgery, salvage procedures may become necessary. Patients who fail to respond to any measures may be candidates for end stage revision to a resection arthroplasty.

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