Evaluation and management of chronic total hip instability

Given the increasing number of total hip arthroplasty procedures being performed annually, it is imperative that orthopaedic surgeons understand factors responsible for instability. In order to treat this potentially complex problem, we recommend correctly classifying the type of instability present based on component position, abductor function, impingement, and polyethylene wear. Correct classification allows the treating surgeon to choose the appropriate revision option that ultimately will allow for the best potential outcome.

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Background
Instability following primary total hip arthroplasty (THA) is the most common indication for revision arthroplasty and the prevalence of chronic instability has been reported to range between < 1% to 7% after primary THA, and as high as 18% in revision THA.

Historically, the surgical approach employed for arthroplasty has been associated with the incidence of post-operative instability. The posterior approach has been associated with rates as high as 9.5%, which has mainly been attributed to posterior capsulectomy or lack of capsular repair. Anterior-based approaches have had reportedly lower rates, but with routine use of larger femoral heads, better stem options for restoration of femoral offset and meticulous capsular repair, rates of instability, regardless of surgical approach, have become asymptotic and are < 1%.

This review article presents the major factors governing THA stability, defines types of THA instability, depicts how to evaluate the patient pre-operatively, and illustrates different treatment options available and their associated clinical outcomes.

Defining instability
Post-operative instability of THA has been classified as either early or late. Woo and Morrey reported that 59% of dislocations occurred within the first three months post-operatively and 77% within the first year. Early instability can often be effectively managed with closed reduction, bracing and proper education regarding hip precautions, assuming proper component position. Closed reduction in the acute setting has been successful as described by Joshi with 81% experiencing no further dislocations. Early dislocators are, however, at risk of developing chronic instability. Late dislocation beyond the peri-operative period is typically due to a different aetiology.

Different types of instability have been defined by Wera and Paprosky: type I – acetabular component malposition, type II – femoral component malposition, type III – abductor deficiency, type IV – soft-tissue/bony impingement, type V – eccentric polyethylene wear and type VI – unknown aetiology.

Factors governing THA stability
Restoration of hip biomechanics. As outlined by Sir John Charnley, THA is based on the fundamental concept of restoring hip biomechanics. This is achieved by identification of the centre of rotation of the hip, restoration of femoral offset and restoration of leg length. We believe that these factors converge to a ‘sweet spot’ – the hip should not be implanted too tightly, in order to avoid soft-tissue irritation, excessive leg length, and a vaulting gait. Equally, sufficient abductor complex tension must be achieved to avoid a Trendelenberg gait, and instability. Soft-tissue balancing is, in short, necessary to achieve clinical success and a stable THA.

Component factors. The stability of THA is contributed to by component factors such as the size of the femoral head. Maximising the head diameter results in greater excursion, the distance the femoral head must travel in order to dislocate once the neck of the prosthesis impinges on the acetabular component (Fig. 1).
While this is a key factor, it is important that it forms part of a THA adhering to all core principles as, in isolation, a large femoral head component is unlikely to prevent dislocation.

Further to this, maximising the ratio between head and neck diameters conserves the excursion conferred by a large head (Fig. 2). The use of components with larger, collared or tapered necks reduces excursion as they impinge earlier in the arc of movement in the hip, thus relatively increasing once more the risk of dislocation.

Hip stability can also be improved by appropriate selection of the acetabular component. Most commonly, a neutral acetabular polyethylene liner is used for primary THA but an elevated lip liner placed with the lip positioned in the direction of maximum risk for instability can also confer protection against dislocation. Lateralised liners are also available, designed with thicker polyethylene throughout the entire construct and resulting in increased offset, greater abductor complex tension and, therefore, improved stability. The face changing liner is designed so that placement of the liner in the correct orientation can alter the abduction angle or degree of version by 10° without having to change component position (Fig. 3). While this can be beneficial, instability resulting from component malposition should not be treated primarily with technology and revision to address the problem should be the treatment of choice. In elderly or sick patients unable to undergo major revision surgery, however, use of a constrained liner may represent the best balance of risk and benefit.

Component position. Meticulous positioning of the acetabular and femoral components is the cornerstone of stable THA. The native acetabulum is anteverted 20° and abducted 40°, while the proximal femur is anteverted between 12.5° and 16°. Arthroplasty requires the acetabular component to be placed in between 15° and 25° of anteversion; anterior approaches tend to result in less anteversion than the posterior approach. The abduction angle should be between 35° and 45°, with a goal of 40°. Increased polyethylene wear is seen in components placed with > 45° of abduction because of edge loading.

The concept of combined anteversion has been introduced by Ranawat as a sum of the acetabular and femoral anteversion, an adjunct to Lewinnek’s ‘safe zone’. This is evaluated intra-operatively with the leg positioned neutrally or with slight flexion of the hip; the leg is then internally rotated until the femoral head is symmetrically seated in the acetabular component. The degree of internal rotation represents the combined anteversion. Dorr et al demonstrated using computer navigation that the safe zone for combined anteversion was 25° to 50°; an increase predisposes to anterior instability, while anteversion < 25° increases the incidence of posterior instability. If there is native femoral retroversion, the stem is implanted with the greatest amount of anteversion safely possible and the acetabular component subsequently placed to achieve the appropriate combined anteversion (Fig. 4).

The femoral stem is generally implanted with version referenced from the calcar femorale to match the native version of the proximal femur. In certain clinical scenarios, however, the position of the calcar may be neutral, retroverted or anteverted. The position of most uncemented femoral implants can be changed by only a few degrees but cemented or modular, fluted and tapered uncemented components such as the Sivash Range of Motion (Depuy, Warsaw, Indiana) permit version to be dictated by the surgeon.
Patient factors. Patient factors can also contribute to THA instability. Non-compliance in the peri-operative period can result in initial instability, progressing to chronic instability. Proper education is required but may not always be adequate. Central or peripheral nervous system dysfunction (e.g. Parkinson’s disease) or cognitive impairment may result in an increased risk of chronic instability. Neurological disease or impairment may necessitate use of a different surgical approach or implant to minimise post-operative instability.

Pre-operative patient evaluation

How do you diagnose chronic THA instability? Determining the aetiology of chronic THA instability requires a detailed patient history. Obtaining information about the number of previous hip surgeries, the rationale for any previous revision, the timing of revision after the index procedure and complications associated with the procedure is crucial. Understanding the timing of instability, number of dislocations, any nonoperative management attempted and fullness or swelling associated with a metal-on-metal or large metal head THA, can also help determine the aetiology.

A thorough physical examination is also required. Location of previous incisions may dictate any future surgical approach. While assessing range of movement (ROM) may be intimidating because of the risk of causing a dislocation in the outpatient clinic setting, an apprehension sign can indicate the position in which the hip is unstable. Assessing the strength of the abductor complex against resistance, both in the supine and lateral decubitus position, can yield further information relating to the potential aetiology of instability. A comprehensive neurovascular examination of the affected lower extremity as well as a gait analysis is important - patients with a significant Trendelenberg gait may have abductor dysfunction, which should have been identified in the strength-testing phase of the exam. The last component of the physical exam should concentrate on leg length; if a discrepancy is present, inadequate soft-tissue tensioning may be the reason for chronic instability.

Obtaining an erythrocyte sedimentation rate and C-reactive protein is critical to exclude periprosthetic infection. It is important to remember that patients with such infections may present with chronic instability owing to pus within the joint, leading to a non-concentric reduction of the femoral head within the acetabular liner. Elevated inflammatory markers should prompt hip aspiration with examination of the fluid according to the AAOS clinical guidelines for the diagnosis of peri-prosthetic infection.23 Standard hip radiographs should be obtained, including a standing/weight-bearing anteroposterior (AP) pelvis, AP hip and a frog-leg lateral radiograph. It is imperative to make sure that the entire length of the femoral component is visible radiographically - additional full-length femoral radiographs may be necessary to see the entire prosthesis. In addition, a cross-table lateral radiograph can be very helpful in evaluating the version of the acetabular component. The anteversion is measured as the difference between a horizontal line and a line along the open face of the component.

Fig. 4

Intra-operative photograph demonstrating the measurement of the combined acetabular and femoral anteversion. With the leg positioned neutrally or with slight flexion of the hip, the leg is then internally rotated until the femoral head is symmetrically seated in the acetabular component. The angle between the leg and a line parallel to the floor determines the combined anteversion. The ‘safe zone’ is 25 to 50.

Fig. 5

Radiograph demonstrating the method for measurement of the acetabular component anteversion from a cross-table lateral radiograph. This is determined as the difference between a horizontal line and a line along the open face of the component.
Plain radiographs can often reveal a great deal of information relating to index surgery, especially if it was performed elsewhere. Indicative features include an overmedialised acetabular component, one implanted in a neutral or a slightly retroverted position, the use of a large femoral head for a smaller acetabular component (e.g. 36 mm femoral head for a 50 mm liner), a long femoral neck or an extended offset femoral component. Operation notes may provide additional detail such as the rationale for use of a lateralised or face changing liner.

A detailed pre-operative plan must be constructed and this must include provision of appropriate instruments for explantation of existing components where required.

**Treatment of chronic instability.** Each of the different types of chronic instability should be addressed with a specific strategy (Table I); this informs both the surgical revision plan and patient education and counselling. It is also important to recognise that a secondary cause of instability may be present. This was seen in 21% of patients in Wera et al’s series.

In type I and II instability, the acetabular or femoral components are malpositioned and so treatment is revision of the appropriate components, unless comorbidity or function mandates the more limited option of a change to a lip, lateralised or face changing liner. It is imperative to check the stability of the hip following capsulotomy but
before dislocation. In type III instability, the abductor complex is insufficient and must be managed with a constrained liner. If the liner is cemented into a well-positioned, well-fixed component, then a 3 mm cement mantle should be used to ensure adequate fixation. The abductors should be repaired and advanced to the appropriate tension if at all possible.

The source of impingement in type IV instability must be identified and rectified. The head-to-neck ratio should be maximised by increasing the head diameter and the femoral offset must be restored. Sources of impingement may be bony, such as osteophytes or contracted soft tissues that are not properly balanced.

In type V instability, the eccentric wear of the polyethylene liner in the context of properly positioned acetabular and femoral components should be treated with modular head and liner exchange and an increase in femoral head size if possible. Typically, the neck length is also increased. Pre-operative planning should ensure neck length is checked. If a long neck is already in situ, a more complex revision will be required because of a lack of neck options for reconstruction. Revision for eccentric polyethylene wear is, however, associated with a risk of subsequent dislocation. After all of the previous five aetiologies have been excluded, type VI instability is the diagnosis of exclusion, which the authors suggest should be treated with a constrained liner.

Summary of clinical results

The reported results of treatment for chronic instability have been mixed. When an aetiology has been correctly identified they are better, particularly when abductor insufficiency is not the underlying cause. Wera et al demonstrated a survival rate of 79% at five years, rising to 90% when revisions for type III instability were excluded. In a series by Morrey, removal of sources of impingement alone was least successful (33%) whereas repositioning of malpositioned components was most successful (69%).

In type II instability, the femoral component has been classified as being malpositioned but Daly and Morrey have previously stated that improper version of the femoral component is rarely a cause of instability in isolation. This finding has been echoed by Wera et al, where only 8% of cases were classified as type II instability.

Constrained liners may be implanted de novo or can be cemented into a well-fixed, well-positioned cup. Shadert et al demonstrated excellent results with a constrained acetabular component with only two of 110 (1.8%) patients experiencing symptoms of subluxation. Bipolar designs have been found to have two-year dislocation rates of 19%, demonstrated by Parvizi and Morrey.

Tripolar articulations appear to have clinically superior outcomes to locking ring constructs. Anderson et al demonstrated a dislocation rate of 29% two years following revision with a constrained cup using a metal locking ring. Levine et al found that tripolar constructs were effective at preventing or eliminating instability in 93% of complex cases at a similar follow-up. Dual-mobility components improve stability, ROM, and jump distance by providing an additional articular surface. They were introduced in France in the 1970s and have spread throughout the world as an option to treat instability. A small metal head articulates with a large polyethylene head which then articulates with a polished metal acetabular component. Such components have also shown promising results as a treatment for instability with survivorship of components at five years of 94.5% to 98% and a dislocation rate of 1.1% to 5.5%.

In type IV instability, Toomey et al demonstrated that removal of the source of impingement along with exchange of modular components was fairly successful at preventing further dislocation in 77% of patients at 5.8 years.

Chronic THA instability is a challenging problem and the most common reason for revision surgery. Correct classification is based on history, physical exam, imaging and intra-operative assessment. Once properly classified, the problem can be addressed in a systematic manner.

References