

Revision Total Hip Arthroplasty for Instability: Surgical Techniques and Principles

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Abstract

Instability is one of the most common complications after total hip arthroplasty. Fortunately, instability usually occurs as a single episode and can successfully be treated nonsurgically in many instances. However, recurrent instability may require surgical treatment. Although many studies related to instability exist, the etiology and the optimal management of recurrent instability are not well known and continue to be investigated. It is important to understand the principles of management and surgical techniques for the treatment of recurrent instability, including the use of constrained liners.

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Total hip arthroplasty is one of the most successful orthopaedic procedures and is highly effective in relieving pain and improving function.¹⁻³ Unfortunately, some patients have complications, with dislocation being one of the most common.⁴⁻⁸ Dislocation occurs after 0.3% to 10% of primary total hip arthroplasties and after up to 28% of revision total hip arthroplasties.⁴⁻²⁶ The risk of dislocation is influenced by the surgical approach, the underlying diagnosis, the surgical technique, the lifetime of the prosthesis, and the patient's compliance with restrictions.^{6,7,25,27-31} An improved

understanding of the etiology of dislocation and refinements in surgical techniques have led to a decrease in the rate of dislocation over time.^{1,5,6,8,10,19,20,28,32-35} Although most dislocations after total hip arthroplasty are single episodes that can be managed nonsurgically, some patients require surgical intervention to address recurrent dislocation.^{7,8,26,28,35}

The choice of surgical technique to manage recurrent dislocation depends on the etiology of the problem.³⁶ Revision arthroplasty for the treatment of recurrent dislocation is more likely to be successful when a

cause for the dislocation has been identified.^{26,35} In addition, the timing of the onset of the dislocation influences the decision concerning treatment, especially with regard to surgical intervention.^{37,38} Early dislocations—that is, those occurring within a few days to months after the index surgery—are unlikely to recur²⁶ and are much more likely to respond favorably to nonsurgical measures.³⁷ Component malpositioning and abductor insufficiency are two of the most important recognized causes of recurrent dislocation.^{5,8,19,26,28,39} When malpositioning is the cause, revision of the component is the most effective type of surgical intervention.^{6,26,35,39} However, when the etiology of the dislocation is multifactorial or unknown, the best surgical technique for addressing it is often less obvious. The surgical options available for the treatment of recurrent dislocation consist of component revision,^{4,16,35,39,40} modular component exchange,⁴¹⁻⁴⁴ bipolar arthroplasty,^{22,45} use of a larger femoral head,⁴⁶⁻⁴⁸ soft-tissue reinforcement,^{17,30,32,35,49,50} advancement of

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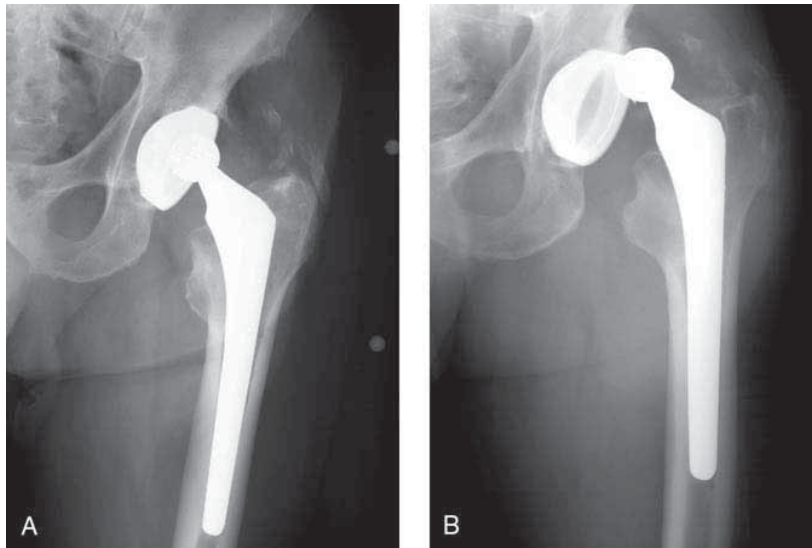


Figure 1 Dislocation following total hip arthroplasty can occur at any time. **A**, AP radiograph made 12 years following a hip arthroplasty. Polyethylene wear is made evident by eccentric seating of the femoral head inside the acetabular liner. **B**, The polyethylene wear was deemed to be responsible for the dislocation in this patient.

the greater trochanter,^{11,51} and use of a constrained liner.^{9,12,24,33,52-54}

Classification of Dislocation

For treatment purposes, dislocation after total hip arthroplasty can be categorized as early or late on the basis of the timing of the onset.^{37,38} Early dislocation usually occurs in the early postoperative period (for example, within 6 months) after the arthroplasty and is often successfully treated with nonsurgical means. In contrast, late dislocation occurs after 5 years and generally requires surgical treatment.³⁷ Dislocations occurring between 6 months and 5 years may be categorized as intermediate. This temporal classification is useful because it highlights the differences in the etiology of the dislocation in each category, which in turn determine the type of treatment that is selected. Early to intermediate dislocations are usually the result of older age, female gender (muscular laxity), and cognitive or neurologic im-

pairment. In addition, some factors, including a preoperative diagnosis of femoral neck fracture, osteonecrosis of the femoral head, or inflammatory arthritis, may predispose the patient to early dislocation.^{6,27,55,56} Late dislocation has a multifactorial etiology that can include polyethylene (bearing surface) wear (Figure 1), deterioration in muscle mass, neurologic impairment, and fractures (such as trochanteric avulsion as a result of wear and osteolysis). Additional predisposing factors for late dislocation include younger age (greater wear), female gender (muscle laxity), unrecognized component malpositioning, and prosthesis-bone impingement as a result of a change in body habitus (weight loss). The incidence of late dislocation may be greater than initially appreciated,^{28,37,57,58} and late dislocations account for one third of all dislocations.³⁷ In addition, their cumulative rate increases with longer follow-up, with reported rates of 1%

at 1 month and 1.9% at 1 year, a constant rate of 1% every 5 years, and a 7% rate at 25 years.²⁷

Although most dislocations, particularly those in the early to intermediate category, can be treated nonsurgically, the etiology of the dislocation dictates the most appropriate treatment modality.

Surgical Techniques

Surgical options for the treatment of recurrent dislocation include revision of component(s); exchange of modular components such as the acetabular liner and the femoral head; bipolar arthroplasty, which allows motion between the femoral head and the acetabular liner and also between the acetabular liner and the native acetabular cavity; tripolar arthroplasty, which involves placement of a bipolar prosthesis against an acetabular shell; use of a larger femoral head; soft-tissue reinforcement; advancement of the greater trochanter; and use of a constrained liner.

Revision Arthroplasty

As mentioned previously, component malpositioning is one of the primary causes of recurrent dislocation, and component revision can successfully treat this type of dislocation.^{3,5,19,26,28,39} Identifying the malpositioned component is not always straightforward. Plain radiographs provide limited information regarding the orientation of the acetabular and femoral components. Hence, CT may be needed to more accurately assess component positioning, especially with regard to version of the acetabulum (Figure 2).⁵⁹ Although subtle component malpositioning is difficult to detect on plain radiographs, the radiographs of a dislocated hip should be scrutinized carefully. In addition to showing the direction of the dis-

location, these radiographs can convey other important information (Figure 3). Other critical parameters, such as abductor strength and the overall neurologic status of the patient, can be gleaned from clinical examination. Limb-length discrepancy detected on clinical or radiographic examination can be an important finding as it can be associated with component malpositioning⁶⁰ because intraoperative instability, which may have been caused by a suboptimally positioned component such as a retroverted socket, may have been addressed by lengthening of the femoral neck to increase the soft-tissue tension (Figure 4). Correction of the malpositioned component can simultaneously correct the limb-length inequality. The ultimate and most accurate information regarding component positioning is obtained from intraoperative inspection of the components during revision surgery. If the component is confirmed to be malpositioned, it should be revised to address the recurrent dislocation. An exception may be made for any frail, elderly, or infirm patient, in whom a slightly malpositioned component may be accepted to prevent prolonged surgery for revision of a well-fixed acetabular or femoral component. In these patients, a constrained liner may be used in an effort to prevent recurrent dislocations.

Modular Component Exchange

This surgical treatment involves exchanging the acetabular liner and the femoral head, with the main intention being to “upsized” the femoral head and/or use an elevated liner. This treatment can be successful only if the patient has well-positioned and well-fixed acetabular and femoral components. In addition,

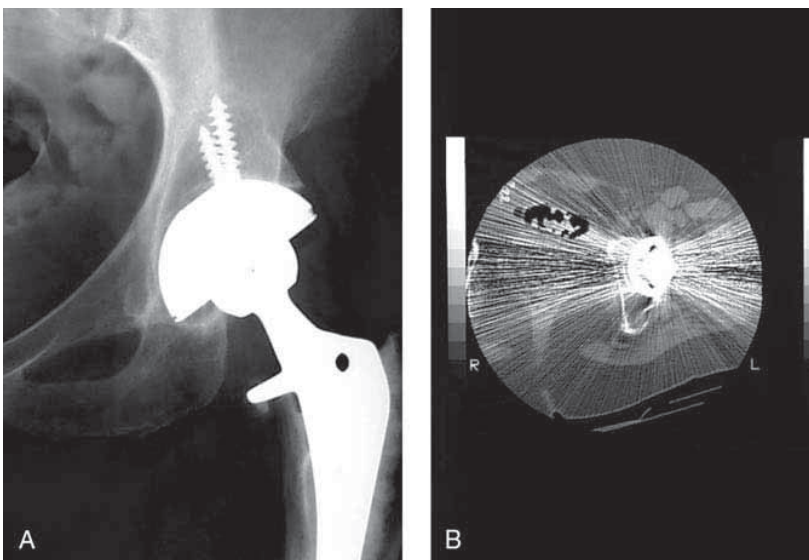


Figure 2 **A**, The components appear to be well positioned on the AP radiograph of the hip of a patient with recurrent dislocation. **B**, CT of the same hip, however, confirms a retroverted acetabular component. Revision of the acetabular component alone in this case was adequate to address the episodes of recurrent dislocation.

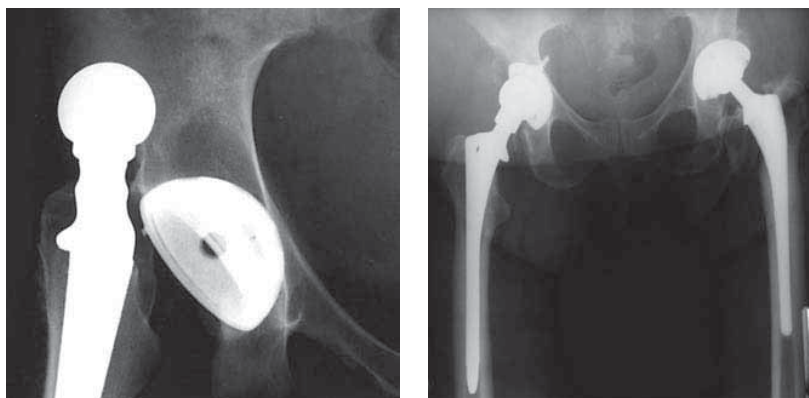


Figure 3 Close scrutiny of the radiographs of a dislocated total hip replacement may be very useful. The retroverted femoral component seen on this radiograph (and confirmed intraoperatively) was the cause of recurrent dislocation in this patient.

tion, the acetabular component in place must be sufficiently large to allow an adequate thickness of polyethylene (a minimum of 4 mm) to be used with the larger femoral head. Several studies have demon-

Figure 4 Suboptimal positioning of the components may lead to intraoperative instability, which may be addressed by increasing the soft-tissue tension, resulting in limb-length discrepancy. A vertical and retroverted acetabular component causing intraoperative instability in the right hip of this patient led to the use of a longer femoral neck, resulting in a marked limb-length discrepancy.

strated success with the use of modular component exchange for the correction of recurrent dislocation after total hip arthroplasty.⁴¹⁻⁴³

Toomey and associates⁴¹ described a series of 13 patients treated with exchange of the femoral head and/or acetabular liner. One patient was lost to follow-up, and only 1 of the remaining 12 patients had recurrent dislocation at a mean of 5.8 years; thus, this surgical treatment had a success rate of 92%, with less extensive morbidity. However, the authors recommended that modular component exchange be used in only selected cases and that each patient be evaluated thoroughly to identify all factors contributing to the dislocation. Additionally, adequate intraoperative stability must be achieved. Despite the success reported by Toomey and associates, modular components can be problematic. In a report on complications related to 20 hip replacements, Barrack and associates⁴⁴ described 15 complications that were related to failure of the modular interface. Complications were attributed to detachment of the femoral head from the trunnion, dislodgment of the polyethylene liner from the shell, and asymmetric rotation of the polyethylene liner. Thus, modular component exchange requires meticulous surgical technique and should be reserved for specific cases.

Bipolar or Tripolar Arthroplasty

Bipolar arthroplasty also has been used as a means of correcting recurrent dislocation.^{22,45} The bipolar device is composed of a small femoral head housed inside a polyethylene shell that is covered by a larger femoral head. Theoretically, there is motion at the interface between the smaller femoral head and the polyethylene liner and also between the larger femoral head and the native acetabulum. Placement of the bipolar prosthesis inside an acetabular component with a liner is known as

tripolar arthroplasty. The large femoral head and the potential for motion at two interfaces account for the high rate of success of this prosthesis in addressing recurrent instability. Grigoris and associates⁴⁶ first described the use of a large bipolar head articulating with a large acetabular shell, also known as tripolar arthroplasty, to treat recurrent dislocation. In their series of eight patients, none had dislocations at a mean of 4.2 years (range, 2.6 to 6.3 years). Ries and Wiedel²² reported success after using a bipolar prosthesis in three patients who had had recurrent dislocations after failure of multiple surgical procedures to address the problem. Parvizi and Morrey⁴⁵ reported the outcomes of bipolar revision total hip arthroplasty for the treatment of recurrent dislocation in a series of 27 patients. Prior to the bipolar hip arthroplasty, all patients had undergone at least two, and a mean of three, stabilizing surgical procedures on the affected hip. At a mean of 5 years after the bipolar arthroplasties, 22 patients (81%) had not had a redislocation. The remaining five patients had had episodes of subluxation or dislocation after the bipolar arthroplasty. Two of the five patients had had only one episode of dislocation, which was treated successfully with immobilization. Two of the remaining three patients required a revision to address continuing dislocation. A constrained liner was used in one patient, and a resection arthroplasty was performed in the second patient. The third patient had continued dislocation episodes but had improved function and pain relief, so a revision was not performed. These studies demonstrate the role of bipolar hip arthroplasty in the salvage management of recurrent dislocation. There are, however, problems associated with the

use of bipolar arthroplasty, the most important of which is the potential for medial or superior migration of the prosthesis with time. In addition, groin pain appears to be a frequent problem associated with the use of this prosthesis. Because of these problems, we do not use bipolar arthroplasty as a main-line treatment of recurrent dislocation.

Large Femoral Head

The arc of motion required to dislocate a prosthetic head is directly related to the diameter of the head. Therefore, with larger femoral heads, a greater volume of the head needs to be displaced from the acetabulum for dislocation to occur. Because of this, large femoral heads have been used as a surgical treatment modality to address recurrent dislocation. Beaulé and associates⁴⁷ reported on the use of a jumbo femoral head to treat recurrent dislocation in a group of 12 patients who had had an average of four previous operations after an average of seven dislocations. These patients underwent revision total hip arthroplasty with the use of a femoral head with an average diameter of 44 mm (range, 40 to 50 mm). A bipolar head articulating with a fixed socket (a tripolar construct) was used in 10 hips, and a modular head (unipolar) was used in the other two hips. After an average duration of follow-up of 6.5 years (range, 3.2 to 11.8 years), 10 hips had had no additional episodes of dislocation. One hip had dislocated within 1 week after the revision total hip arthroplasty, necessitating revision surgery to reposition the acetabular component. The 12th hip remained stable; however, the patient died 14 months postoperatively of unrelated causes.

Amstutz and associates⁴⁸ described the use of a jumbo head in

29 patients with recurrent dislocations. They noted that, in addition to the larger femoral head, reorientation of the bearing surface was required in most patients. Although the early use of jumbo femoral heads has been successful, the downside to the use of a very large femoral head is the necessity to simultaneously insert a thin polyethylene liner. In addition, the longevity of total hip prostheses with a jumbo head has not been determined.

Soft-Tissue Reinforcement and Advancement of the Greater Trochanter

Other, currently less used surgical procedures for addressing recurrent dislocation include reinforcement of the soft tissues—namely, the abductor mechanism—around the hip and trochanteric advancement.^{11,51} The main problem associated with these procedures is the variability in outcome.^{11,17,30,32,35,49-51} These procedures can also be technically demanding and are likely to fail if used in patients with component malpositioning. Therefore, soft-tissue reinforcement and trochanteric advancement are being used with less frequency and only in cases in which component position has been absolutely determined to be acceptable. Additionally, these procedures should be reserved for patients who are poor candidates for other options such as the use of a constrained liner. For example, soft-tissue enhancement should be considered for a young, high-demand patient or a patient with a well-fixed cemented acetabular component in whom other options cannot be used.

Constrained Liners

The constrained acetabular liner is an invaluable tool in the armamentarium for surgical treatment of recurrent

dislocations. Its success has been widely demonstrated.^{9,12,24,33,52-54} This device is especially suited for the treatment of recurrent dislocation secondary to soft-tissue (abductor) deficiency. It is also an excellent option for patients with recurrent dislocation of unknown etiology, elderly patients in whom the components are well fixed, and patients with neurologic impairment. In other words, constrained liners are used as a salvage treatment option in the most difficult subset of cases. To our knowledge, Anderson and associates⁹ were the first to describe the use of constrained liners in patients with recurrent dislocation. They reported a success rate of 72% in a study of 18 patients followed for a mean of 31 months (range, 24 to 64 months) after the use of this device. Disassembly and disengagement of the Arthropor II constrained component (Joint Medical Products, Stamford, CT) accounted for four of the six failures. The only factor predictive of failure was an increased acetabular abduction angle of the metallic acetabular cup. At the time of follow-up, there was no radiographic or clinical evidence of loosening of the acetabular component.

One of the main advantages of a constrained liner is its ability to provide stability without the need to revise a well-fixed and well-positioned acetabular component. Callaghan and associates³⁴ reported the clinical and radiographic outcomes of 31 revision total hip arthroplasties in which a constrained liner had been cemented into a well-fixed cementless acetabular shell. At an average of 3.9 years postoperatively, 29 constrained liners (94%) remained securely fixed in the cementless shell, and only 2 liners had failed. One of the failed liners had separated from

the cement, and the other had failed as a result of fracture of the capturing mechanism. Each hip was successfully revised with another cemented constrained liner. No acetabular component showed radiographic evidence of progressive loosening or associated osteolysis. The authors drew attention to the importance of proper preparation of the liner, correct sizing of the component, and the use of optimal cementing technique. Their meticulous surgical technique may explain the good results despite the suboptimal outcomes of this technique in other studies.^{8,13} This study demonstrated favorable short-term outcomes following cementing of a constrained tripolar liner, but the authors stressed that the shell must be secure and well positioned.

The use of a constrained liner for the treatment of recurrent dislocations can be rewarding when no discrete cause for the dislocations can be identified or when the dislocations are deemed to be caused by soft-tissue deficiency. It is critical that, before using a constrained liner, the surgeon ensure that the components are well positioned and that subtle malpositioning is not the cause of the dislocation. Assessment of component positioning may require preoperative CT and close scrutiny during surgery.

Surgical Technique

There are some important technical details that need to be kept in mind during implantation of a constrained liner to maximize the success of this procedure. The acetabular component needs to be well exposed, and the previous liner must be removed to allow assessment of the positioning of the component. Any previously placed screws also need to be removed to allow testing of the fixa-

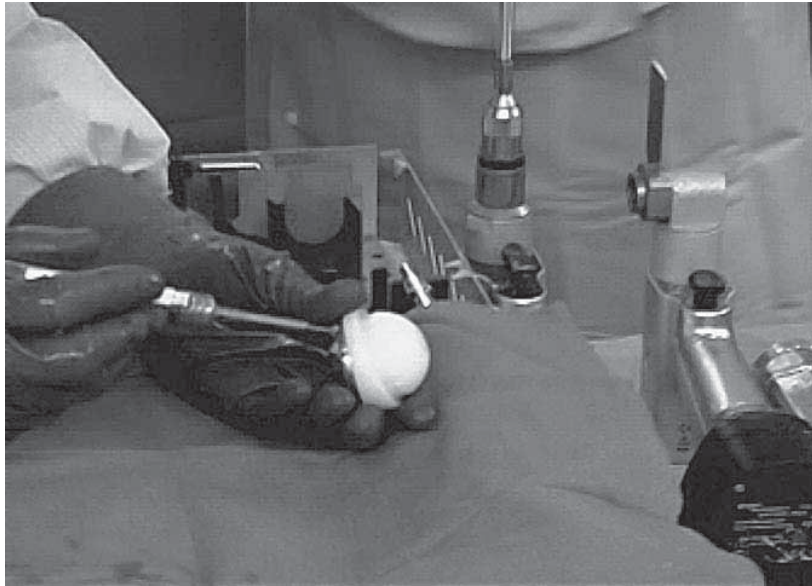


Figure 5 Meticulous attention to detail is pertinent when a constrained liner is being cemented into a well-fixed acetabular liner. Removing the circumferential ring and scoring the back of the constrained liner in a “spider web” manner is being performed here to allow locking of the cement between the liner and the shell.

tion of the acetabular component. If the acetabular liner is well fixed and the locking mechanism is intact, then a matching constrained liner may be snapped into place. When the cup has a suboptimal or non-functioning locking mechanism, a constrained liner may be cemented in place. With the introduction of modularity, the latter option is becoming more feasible. It is, however, critical that the retained acetabular component be large enough to allow an adequate cement mantle around the constrained liner. Acetabular shells with polished inner surfaces and no screw holes may be scored in a “spider web” pattern (Figure 5). The cement is pressurized to force it into the screw holes. Then the constrained liner is inserted, with the surgeon making sure that it is seated within the shell while simultaneously trying to prevent it from bottoming out. Usually,

2 mm of cement mantle is optimal. In comparison with revision of the acetabular component, cementation of a constrained liner decreases surgical time, decreases blood loss, and does not compromise acetabular bone stock. Cementation of a constrained liner into a secure cementless shell provides a suitable solution to the problem of recurrent total hip dislocation.

Problems With Acetabular Liners

Although constrained acetabular liners have become popular for treating recurrent dislocation, problems related to premature wear, increased radiolucency, and dislodgment of these liners still remain a major concern.⁵² Shrader and associates⁵² evaluated the clinical and radiographic outcomes of 110 constrained-liner arthroplasties, 79 of which had been done for the treatment of recurrent

dislocation and 31 of which had been performed to address absent or grossly deficient soft-tissue attachments noted at the revision total hip arthroplasty. Ninety-eight percent (108) of these revisions were successful, with no subsequent hip dislocation. Only two patients continued to have sensations of subluxation. Radiographic analysis revealed radiolucent lines around the cup in 15 hips (14%). There were nine revisions: six due to deep infection, two due to loosening of the acetabular component, and one due to periprosthetic fracture of the femur. Over time, the increased stresses on an acetabular cup housing a constrained liner theoretically may cause a high rate of loosening and failure. It was noted that most patients in this study had undergone multiple prior reconstructive procedures, which in some cases had resulted in bone and soft-tissue deficiency. In addition, some of the patients were treated with acetabular bone grafting at the time of the revision operation. Therefore, it is conceivable that the high rate of radiolucency observed in this patient population was due to many factors and was not solely related to the use of the constrained cup.

Cooke and associates⁵³ identified three types of early failure of a constrained acetabular implant (Figure 6). In their series, 58 patients underwent revision with use of the constrained acetabular implant for various reasons, including recurrent dislocation (46 patients), reimplantation following a Girdlestone resection (8 patients), correction of limb-length discrepancy (3 patients), and periprosthetic fracture (1 patient). Forty-nine of the constrained acetabular components were inserted into a cementless shell, six were cemented into a preexisting cement-

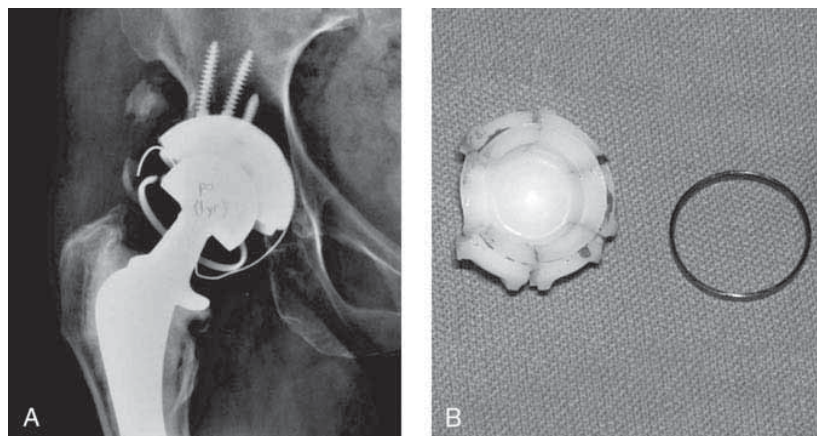


Figure 6 A, AP radiograph of the hip demonstrating failure of the constrained liner. B, The locking mechanism (ring) of the constrained liner has broken.

less shell, two were cemented into a cage, and one was cemented directly into the acetabular bone. Eight patients (14%) required a revision because of failure of the constrained liner, with seven of them having had recurrent dislocations. Failures were described on the basis of the mechanism of implant failure. There were three type I failures (of the bone-prosthesis interface), two type II failures (of the liner locking mechanism), and one type III failure (of the femoral head locking mechanism). In addition to the failures classified by Cooke and associates, a fourth failure mechanism—complete dissociation of the pelvis (type IV)—has been encountered at our institution when a constrained liner was used in combination with a cage (Figure 7).

Cooke and associates⁵³ noted that careful attention to surgical technique may decrease failure rates. Type I failures can be avoided by using supplemental screw fixation for the cementless shell before inserting the constrained acetabular component. The risk of type II failures can be minimized when cementing the constrained liner into the ce-

mentless shell by seating the liner fully into the shell. Scoring or roughening the polyethylene lightly with a burr enhances the grouting bond of the cement and may minimize debonding of the cement-polyethylene interface. The risk of type III failures can be minimized by ensuring that range of motion does not lead to component-component or component-bone impingement.

In short, hip arthroplasty with a constrained acetabular cup should be considered as an option for the surgical treatment of patients with extensive soft-tissue deficiency, deficiency of the abductor mechanism, dislocation with no discrete or identifiable cause, and/or recurrent dislocation despite prior attempted surgical correction. Patients should be selected carefully for treatment with this technique—that is, only after detailed examination for the cause of the dislocation and after it has been determined that other interventions are unlikely to be successful. Prior to inserting a constrained liner, it is crucial that the positions of the femoral and acetabular components be scrutinized.



Figure 7 Complete dissociation of the pelvis in a patient in whom the constrained liner had been used in combination with a cage.

Summary

Surgical management of recurrent dislocation following total hip arthroplasty is a challenging problem. Recognition of the etiology is critical for successful treatment. Close scrutiny of component position is a crucial step in the management of these patients. Subtle component malposition should always be suspected. Revision of the malpositioned component is perhaps the most effective type of surgical intervention in the treatment of recurrent dislocation. During revision surgery, it is imperative that the components be carefully inspected to determine if they are optimally positioned. When revision surgery is planned, the necessary equipment should always be available for revision of the malpositioned component. When dislocation is multifactorial or idiopathic, the potential surgical options include modular component exchange, bipolar arthroplasty, use of a large femoral head, and insertion of a constrained acetabular component. Soft-tissue reinforcement and trochanteric ad-

vancement have variable and less successful results and should be used in only carefully selected cases.

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