Is an Algorithmic Approach to the Treatment of Recurrent Dislocation After THA Effective?

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Abstract

Background The indications for surgical techniques for treatment of recurrent hip dislocation after THA differ, and their rates of achievement of stability may not be similar. **Questions/purposes** We (1) describe our indications for different approaches for recurrent dislocation, (2) outline an algorithmic approach to the management of recurrently dislocating hips after THA, and (3) determine the overall rate of restoration of stability via this algorithmic approach and for each of four procedures with our indications.

Ehsan Saadat, Glenn Diekmann, and Steven Takemoto have no commercial associations (eg, consultancies, stock ownership, equity interest, patent/licensing arrangements, etc) that might pose a conflict of interest in connection with the submitted article. Michael D. Ries is a consultant with intellectual property (royalty income) from Smith and Nephew, Inc (Memphis, TN, USA) and products from Stryker Orthopaedics (Mahwah, NJ, USA). Each author certifies that his institution has approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained if required. This work was performed at the University of California, San Francisco, Medical Center.

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Patients and Methods We retrospectively reviewed 66 patients (69 hips) with revision THA for symptomatic recurrent dislocation from 1993 to 2008. We determined the rate of achievement of stability for the overall patient population and with each revision technique. Minimum followup was 2.8 years (mean, 7.8 years; range, 2.8–12.7 years).

Results Fifty-one of the 69 hips (74%) had no further dislocations while nine (13%) required two revisions and nine (13%) required three or more revisions. Ultimately, all of the 69 hips (100%) were stable at followup. Use of a large (36-mm-diameter) head, constrained cup, trochanteric advancement, correction of malposition, and a combination of techniques was effective in achieving stability in 67%, 68%, 86%, 91%, and 90% of cases, respectively.

Conclusions Separating the treatment of patients based primarily on the presence or absence of (1) component malposition, (2) an intact abductor mechanism, and (3) implants accommodating a large-diameter femoral head, we were able to achieve hip stability with one operation in 74% of cases.

Level of Evidence Level IV, therapeutic study. See the Guidelines for Authors for a complete description of levels of evidence.

Introduction

Recurrent dislocation is a relatively common cause of failure of THA, second only to aseptic loosening as a cause for reoperation after THA [20, 30]. The reported rate of dislocation ranges from 1% to 21% after primary THA [8, 16, 21, 26] and 9% to 21% after revision THA [9, 24, 30]. Several factors contribute to this risk, including a history of

previous hip surgery or revision THA [1, 31], posterior surgical approach [4], malposition of one or both components [13], low femoral head/neck ratio [2], inadequate soft tissue tension [22], insufficient or weak abductor muscles [22], trochanteric nonunion [1], obesity [17], presence of cerebral dysfunction [32], and noncompliance or extremes of positioning in the perioperative period [28]. Sixteen percent to 59% of patients with a hip dislocation after THA develop recurrent dislocations [6, 9, 14, 19]. Likely contributing factors include muscular weakness, excessive ROM or component malposition (leading to impingement), small femoral head size or low head/neck ratio, and trochanteric nonunion.

Mechanical factors contributing to instability can generally be separated into those resulting in component impingement (component malposition, low head/neck ratio, and excessive ROM) and those resulting in soft tissue laxity (trochanteric nonunion, complete segmental proximal femoral bone loss, and abductor weakness) in which the “jump distance” is exceeded. Correct identification of the underlying cause of dislocation with attention to the above categories guides the surgical technique in addressing the problem. Several authors have investigated the effectiveness of individual techniques in management of dislocations [1, 7, 21, 23, 25, 27–29]. The reported success rates of revision surgery in preventing further dislocation varied considerably. One study found removal of impingement alone was least successful (33%), whereas repositioning of malpositioned components was most successful (69%) [21]. Recurrent dislocations thought to be the result of stretching of intact soft tissues in the presence of well-positioned implants have been treated with trochanteric advancement, achieving stability in 90% of the patients [7]. Toomey et al. [29] reported modular component exchange of the head and/or liner, combined with removal of impingement, prevented further recurrence of dislocation in 10 of 13 patients (77%) at 5.8 years. Alberton et al. [1] also found revision to 28- and 32-mm heads, rather than 22-mm heads, resulted in a lower risk of dislocation (6% versus 11%). Although these various authors individually described and studied each of the above treatments, they did not describe results of different techniques to treat dislocations.

We use different approaches to treat recurrent dislocation for different indications based on an algorithmic approach to the management of recurrently dislocating hips after THA. We questioned (1) what the rate of achievement of stability was using this algorithmic approach in our patient population and (2) what the rate of achievement of stability was for each of four procedures with our indications.

Patients and Materials

We retrospectively identified all 72 patients with 75 symptomatic recurrent total hip dislocations who had surgery between 1998 and 2008. We defined “recurrent dislocations” as two or more dislocations that were not controlled with nonoperative treatment. We were unable to retrieve the exact number of episodes of dislocations for each patient from the records. Sixty-one of the patients were referred to us for treatment of recurrent dislocation and 11 were patients in the senior author’s (MDR) practice. Eight of the 11 patients in the senior author’s practice were revision THAs for other reasons that subsequently developed recurrent dislocations and three of the 11 developed recurrent dislocations after primary THA. Six of the 72 (8%) patients were either lost to followup or had incomplete records at the time of review. This left 66 patients who had operations on 69 hips. Fifty-two percent of patients were women and 48% men, and their ages ranged from 33 to 86 years. Patient body mass index (BMI) ranged from 17.9 to 53.5; 19% of patients had a BMI of 30 or more. Eleven (16%) hips had a previous history of infection, which had necessitated a two-stage revision surgery before the first episode of dislocation; the revision surgery for infection included removal of original hardware and implantation of an antibiotic-impregnated cement spacer, followed by reimplantation of hardware. Seventeen patients (25%) had abductor deficiency. We defined abductor deficiency as anatomic loss of the abductor muscle attachment to the proximal femur due to either trochanteric nonunion or segmental loss of proximal femoral bone stock. All of the patients had late dislocations (after 1 year); we treated dislocations before 1 year nonoperatively. The minimum followup was 2.8 years (mean, 7.81 years; range, 2.8–12.7 years). No patients were recalled specifically for this study; all data were obtained from medical records and radiographs.

During the study period, we performed one of four operations depending on the diagnosed problem: (1) correction of component malposition, (2) replacement of the femoral head with a large-diameter (36-mm) head, (3) trochanteric advancement, and (4) conversion of the acetabular component to a constrained implant. We chose not to use a bipolar prosthesis in this series since the bipolar bearing articulates with the native pelvis, which can result in pain and migration. The indications for each of the four surgeries differed, with the goal of identification and correction of the mechanical cause of instability. The indication for correction of component malposition was inadequate or excessive acetabular anteversion or vertical inclination, which we considered a cause of component impingement that resulted in instability (Fig. 1).

The indication for use of a large-diameter femoral head was adequately positioned components with a small (≤ 28 -mm-diameter) femoral head (Fig. 2). Trochanteric advancement was indicated in the setting of adequately positioned

Fig. 1A–D Radiographs illustrate the case of a 62-year-old woman who experienced recurrent anterior hip dislocations after primary THA despite use of a 36-mm femoral head. **(A)** An AP pelvic radiograph shows the position of the components. **(B)** A crosstable lateral radiograph demonstrates the acetabular component was excessively anteverted. **(C)** AP and **(D)** crosstable lateral radiographs show the patient's hip after acetabular revision was performed to correct component malposition.

components where the femoral head size could not be increased. The trochanter was reattached using vertical and horizontal cables [12]. We used this technique more frequently in the earlier phase of the study, when large-diameter femoral heads were not available (Fig. 3). The indication for a constrained cup was complete loss of proximal femoral bone stock, including the abductor attachment in which the “jump height” was relatively easily exceeded, and when other revision procedures failed to control hip instability (Fig. 4). We sutured the posterior capsule and short external rotators, if present, to the posterior border of the proximal femur or abductors, but there were no other specific soft tissue procedures performed to improve stability. We did not perform revision of the entire femoral component to correct inadequate offset or leg length in any patient.

We based the decision to use one or more techniques on the identification and correction of mechanical factors we considered the cause of instability (Fig. 5). We considered trochanteric advancement contraindicated if bone stock in the greater trochanter was osteolytic or osteopenic, which could have led to greater risk of nonunion, and considered correction of malposition contraindicated if the components were well positioned based on preoperative AP pelvic and crosstable lateral hip radiographs. We considered use of a large head contraindicated if the acetabular component was too small to accommodate a large head or the femoral component was nonmodular; we did not perform femoral component revision. A constrained cup was considered contraindicated in any patient in whom mechanical abnormalities were identified that could be controlled with alternative techniques.

The senior author was the surgeon for all cases. The surgeon used four different surgical procedures to treat recurrent dislocations. To prevent “double counting,” we divided patients into two groups and studied them separately. The first group consisted of patients who received only a single technique, while the second group had a combination of techniques during the first operation to control instability.

The postoperative regimen was uniform for all patients. This included placement of an abduction pillow immediately after wound closure in the operating room, followed by early mobilization as soon as possible under the supervision of a trained physical therapist familiar with our practice (usually on the first postoperative day). Weightbearing was restricted to toe touch for 6 weeks after surgery in all patients. If we performed trochanteric osteotomy or bone grafting, we restricted weightbearing to 50% for an additional 6 weeks. We instructed all patients in either anterior or posterior hip precautions, depending on the preoperative pattern of instability, and advised against positioning the hip in extremes of range of motion (ROM).

Fig. 2A–B Radiographs illustrate the case of a 68-year-old man who developed recurrent dislocations after previous THA using a 28-mm femoral head despite correct implant position. (A) An AP radiograph shows the position of the components. (B) An AP radiograph shows the patient's hip after revision of the head and liner was performed to increase the head diameter to 36 mm.

Fig. 3A–B Radiographs illustrate the case of a 72-year-old woman who had undergone previous THA with a nonmodular femoral component and subsequent acetabular revision and developed recurrent anterior dislocations. (A) An AP radiograph shows the position of the components. The femoral component was nonmodular; thus, femoral head size could not be increased without revising the femoral component, which was stable and in good condition. The components were considered to be in good position. (B) Therefore, trochanteric advancement was performed to control instability.

Patients returned to clinic for a clinical and radiographic examination of the hip at 6, 12, 24, and 52 weeks postoperatively and then yearly thereafter. Radiographs included AP pelvic and lateral hip views. Polyethylene wear was not measured radiographically. The clinical examination included an assessment of gait, hip ROM, and strength at each visit.

For all patients, we recorded demographic and clinical data, including age, sex, BMI, history of previous ipsilateral hip infection, and abductor deficiency. The posterior surgical approach was used for every case. We defined success as the achievement of a stable hip and maintenance of stability for at least 2 years after surgery.

Treatment methods used were separated into three time periods during the study (Table 1). Pearson's chi square test was used to test for differences in proportions between patient demographics and revision techniques used during each time period.

Results

The majority of cases were treated with a large head or constrained cup (28% each), followed by trochanteric advancement (20%), a combination of techniques (16%), and a correction of malposition (9%) (Table 2). Of all

Fig. 4A–B Radiographs illustrate the case of an 86-year-old man who had undergone multiple previous revision THAs complicated by infection and massive femoral and acetabular bone loss treated with removal of the components and insertion of an articulated antibiotic-impregnated cement spacer. (A) An AP radiograph demonstrates posterior dislocation of the femoral spacer from the acetabular spacer. (B) An AP radiograph shows the patient's hip after revision THA was performed using a trabecular metal augment (Zimmer, Inc, Warsaw, IN, USA), a reconstructive cage (Contour®; Smith and Nephew, Inc, Memphis, TN, USA), a constrained acetabular component (Reflection Interfit®; Smith and Nephew), which was cemented into the cage, and a 28-mm-diameter femoral head. A constrained component was chosen because the abductors were deficient as a result of massive segmental proximal femoral bone loss.

Fig. 5 A chart shows the decision-making algorithm for surgical treatment of recurrent hip dislocations after THA based on factors that appeared to cause instability.

Table 1. Demographics and time period of treatment methods

Variable	Number of hips	Large head	Constrained cup	Trochanteric advancement	Correction of malposition	Combination	p Value
Number of hips		19	19	14	6	11	
Time period							
1993–2000	19	10.5%	47.4%	35.7%	16.7%	18.2%	0.004
2001–2003	22	10.5%	26.3%	50%	33.3%	54.6%	
2004–2008	28	79%	26.3%	14.3%	50%	27.3%	
Sex							
Male	36	52.6%	68.4%	28.6%	66.7%	45.5%	0.211
Female	33	47.4%	31.6%	71.4%	33.3%	54.6%	
Age							
33–50 years	25	57.9%	21.1%	35.7%	33.3%	27.3%	0.368
51–70 years	24	26.3%	36.8%	28.6%	33.3%	54.6%	
> 70 years	20	15.8%	42.1%	35.7%	33.3%	18.2%	
Body mass index							
≤ 25	18	26.3%	36.8%	28.6%	16.7%	9.1%	0.467
25.1–30	21	36.8%	26.3%	28.6%	33.3%	27.3%	
> 30	13	31.6%	5.3%	21.4%	16.7%	18.2%	

Table 2. Rates of achievement of stability for interventions used in treatment of recurrent dislocations after THA

Intervention	Number of hips	Rate of achievement of stability
Large femoral head	19	67%
Constrained cup	19	68%
Trochanteric advancement	14	86%
Correction of malposition	6	91%
Combination of techniques	11	90%

recurrently dislocating hips, 51 of the 69 hips (74%) were successfully managed with one revision operation, nine (13%) required two revisions, and nine (13%) required three or more revisions for successful management of recurrent dislocations. Use of a large (36-mm-diameter) head, constrained cup, trochanteric advancement, correction of malposition, and a combination of techniques was effective in achieving stability in 67%, 68%, 86%, 91%, and 90% of cases, respectively (Table 2). Ultimately, all of the 69 hips (100%) were stable at followup.

A greater proportion of cases were treated with constrained cups earlier in the study period and a greater proportion of cases were treated with large heads later in the study period (Table 1). Twenty patients had revision THA with a femoral head diameter of 28 mm or less in an acetabular cup with a diameter of 58 mm or more. Of these, 14 were constrained cup revisions, seven of which achieved stability with one operation; two were trochanteric advancements, one of which achieved stability with one operation; two were correction of malposition, one of

which achieved stability with one operation; and two were a combination of techniques, both of which achieved stability with one operation.

Discussion

Surgical treatment options for management of recurrent dislocation after THA include trochanteric advancement, correction of malpositioned components, improving the head-to-neck ratio by use of a larger femoral head [15, 28] or bipolar prostheses [23, 25], and constrained acetabular cups [27]. However, the specific indications for each type of treatment and rate of achievement of stability are not necessarily similar. In this retrospective study, we (1) described our indications for different approaches for recurrent dislocation, (2) outlined an algorithmic approach to the management of recurrently dislocating hips after THA, and (3) determined the overall rate of restoration of stability using this algorithmic approach in our patient population and for each of four specific procedures with our indications.

Readers should be aware of the limitations of our study. First, while we report our experience with a consecutive series of cases of a difficult problem, our surgical treatments for each patient were individualized and had differing indications. As such, we were unable to directly compare the four techniques to one another and can only report a success rate for each technique individually. Second, since this was a retrospective study, we were unable to compare groups of patients or randomize groups of patients

Table 3. Comparison of our rates of achievement of stability to those of previous studies

Study	Description of study	Number of hips	Large femoral head	Constrained cup	Trochanteric advancement	Correction of malposition
Shrader et al. [27] (2003)	Retrospective descriptive study	110		Success rate 98%		
Goetz et al. [10] (1998)	Retrospective descriptive study	56		Success rate 96%		
Bystrom et al. [4] (2003)	Retrospective study	42,987 from the Norwegian Arthroplasty Registry	Failure rate ratio of 4 for small heads (< 32 mm)			
Ekelund [7] (1993)	Retrospective descriptive study	21			Success rate 80%	
Kelley et al. [15] (1998)	Prospective randomized study of primary THAs	31	Smaller head size (22 mm) increased rate of dislocations			

to different surgical techniques. Third, the patient population was not large enough to perform multivariate analysis and identify specific patient characteristics associated with success or failure of surgical treatment. Forth, most patients in our study were referred for treatment of instability after THA and may not be representative of patient populations in other practices with hip instability. However, despite these limitations, our study illustrates an algorithm for treatment and the efficacy of different surgical techniques used for specific indications to control recurrent dislocation after THA in a single cohort of patients.

Using an algorithmic approach, we separated the treatment of our patients based on the factors that appeared to cause instability (Fig. 5). These included presence or absence of (1) component malposition, (2) an intact abductor mechanism, and (3) implants accommodating a large-diameter femoral head. (1) If the components were malpositioned, correction of malposition was performed; (2) if the abductors were deficient, a constrained cup was used; and (3) if the implants would accommodate a large-diameter femoral head, the head size was increased. Our overall rate of achieving a stable hip with one operation was 74% using this algorithm for treatment. However, the rate of achievement of a stable hip with this approach is difficult to compare to previous published reports since other investigators have generally reported the results of a single technique used for specific indications (Table 3).

Our data suggest that, while the indications differed for the various procedures, correction of malposition and trochanteric advancement were most likely to achieve stability in a chronically unstable hip after THA. However, the rates of success for each specific procedure did not necessarily reflect a relative superiority or inferiority of one method over another since the indications for each

procedure were different. A constrained articulation is an effective technique to control instability. However, the constraining ring can also restrict ROM, leading to impingement and increased stresses at the liner locking mechanism and the implant-bone interface. In our experience, use of a constrained acetabular cup with a dual locking mechanism and 28-mm femoral head is associated with a relatively high rate of mechanical failure. This is unlike reports by Shrader et al. [27] or Goetz et al. [10], where up to 96% of patients had no further dislocation with constrained components. The higher rate of failure in our series compared to other reports may be related to the differences in implant design or length of followup. Somewhat surprisingly, we found a 36-mm femoral head was not effective in controlling instability in approximately 30% of our cases. Though large femoral head sizes contribute to stability by increasing both ROM to impingement and jump distance [5], it is possible, in cases of recurrently dislocating hips after THA, that a 36-mm femoral head size may not be adequate in providing long-term stability. Also, the use of a 36-mm femoral head did not reduce the rate of dislocation after THA if the abductor mechanism was absent [18]. The use of jumbo-sized femoral heads (> 39 mm) to restore joint stability had encouraging medium-term outcomes [3, 11, 25]. During our study, a 36-mm diameter femoral head was the largest diameter available to us. However, we would expect currently available heads, which are larger than 36 mm, to provide more stability.

In summary, the choice of specific surgical techniques to control chronic hip instability after THA depends on identification and correction of the mechanical factors contributing to instability. Such techniques have differing indications, and the rate of achievement of stability differs for each technique and clinical situation. Using an

algorithmic approach to separate the treatment of our patients based primarily on the presence or absence of (1) component malposition, (2) an intact abductor mechanism, and (3) implants accommodating a large-diameter femoral head, we were able to achieve a stable hip with one operation in 74% of our cases.

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References

1. Alberton GM, High WA, Morrey BF. Dislocation after revision total hip arthroplasty: an analysis of risk factors and treatment options. *J Bone Joint Surg Am.* 2002;84:1788–1792.
2. Bartz RL, Nobel PC, Kadakia NR, Tullos HS. The effect of femoral component head size on posterior dislocation of the artificial hip joint. *J Bone Joint Surg Am.* 2000;82:1300–1307.
3. Beaulé PE, Schmalzried TP, Udomkiet P, Amstutz HC. Jumbo femoral head for the treatment of recurrent dislocation following total hip replacement. *J Bone Joint Surg Am.* 2002;84:256–263.
4. Bystrom S, Espehaug B, Furnes O, Havelin LI. Femoral head size is a risk factor for total hip luxation: a study of 42,987 primary hip arthroplasties from the Norwegian Arthroplasty Register. *Acta Orthop Scand.* 2003;74:514–524.
5. D'Angelo F, Murena L, Zatti G, Cherubino P. The unstable total hip replacement. *Indian J Orthop.* 2008;42:252–259.
6. Dorr LD, Wolf AW, Chandler R, Conaty JP. Classification and treatment of dislocations of total hip arthroplasty. *Clin Orthop Relat Res.* 1983;173:151–158.
7. Ekelund A. Trochanteric osteotomy for recurrent dislocation of total hip arthroplasty. *J Arthroplasty.* 1993;8:629–632.
8. Etienne A, Cupic Z, Charnley J. Postoperative dislocation after Charnley low-friction arthroplasty. *Clin Orthop Relat Res.* 1978;132:19–23.
9. Fackler CD, Poss R. Dislocation in total hip arthroplasties. *Clin Orthop Relat Res.* 1980;151:169–178.
10. Goetz DD, Capello WN, Callaghan JJ, Brown TD, Johnston RC. Salvage of a recurrently dislocating total hip prosthesis with use of a constrained acetabular component: a retrospective analysis of fifty-six cases. *J Bone Joint Surg Am.* 1998;80:502–509.
11. Grigoris P, Grecula MJ, Amstutz HC. Tripolar hip replacement for recurrent prosthetic dislocation. *Clin Orthop Relat Res.* 1994;304:148–155.
12. Huffman GR, Ries MD. Combined vertical and horizontal cable fixation of an extended trochanteric osteotomy site. *J Bone Joint Surg Am.* 2003;85:273–277.
13. Jolles BM, Zangger P, Leyvraz PF. Factors predisposing to dislocation after primary total hip arthroplasty: a multivariate analysis. *J Arthroplasty.* 2002;17:282–288.
14. Joshi A, Lee CM, Markovic L, Vlatas G, Murphy JC. Prognosis of dislocation after total hip arthroplasty. *J Arthroplasty.* 1998;13:17–21.
15. Kelley SS, Lachiewicz PF, Hickman JM, Paterno SM. Relationship of femoral head and acetabular size to the prevalence of dislocation. *Clin Orthop Relat Res.* 1998;355:163–170.
16. Khadod M, Barber T, Paxton E, Namba R, Fithian D. An analysis of the risk of hip dislocation with a contemporary total joint registry. *Clin Orthop Relat Res.* 2006;447:19–23.
17. Kim Y, Morshed S, Joseph T, Bozic K, Ries MD. Clinical impact of obesity on stability following revision total hip arthroplasty. *Clin Orthop Relat Res.* 2006;453:142–146.
18. Kung PL, Ries MD. Effect of femoral head size and abductors on dislocation after revision THA. *Clin Orthop Relat Res.* 2007;465:170–174.
19. Lindberg HO, Carlsson AS, Gentz CF, Pettersson H. Recurrent and non-recurrent dislocation following total hip arthroplasty. *Acta Orthop Scand.* 1982;53:947–952.
20. McCollum DE, Gray WJ. Dislocation after total hip arthroplasty: causes and prevention. *Clin Orthop Relat Res.* 1990;261:159–170.
21. Morrey BF. Instability after total hip arthroplasty. *Orthop Clin North Am.* 1992;23:237–248.
22. Padgett DE, Warashina H. The unstable total hip replacement. *Clin Orthop Relat Res.* 2004;420:72–79.
23. Parvizi J, Morrey BF. Bipolar hip arthroplasty as a salvage treatment for instability of the hip. *J Bone Joint Surg Am.* 2000;82:1132–1139.
24. Paterno SA, Lachiewicz PF, Kelley SS. The influence of patient-related factors and the position of the acetabular component on the rate of dislocation after total hip replacement. *J Bone Joint Surg Am.* 1997;79:1202–1210.
25. Ries MD, Wiedel JD. Bipolar hip arthroplasty for recurrent dislocation after total hip arthroplasty: a report of three cases. *Clin Orthop Relat Res.* 1992;278:121–127.
26. Ritter MA. Dislocation and subluxation of the total hip replacement. *Clin Orthop Relat Res.* 1976;121:92–94.
27. Shrader MW, Parvizi J, Lewallen DG. The use of a constrained acetabular component to treat instability after total hip arthroplasty. *J Bone Joint Surg Am.* 2003;85:2179–2183.
28. Soong M, Rubash HE, Macaulay W. Dislocation after total hip arthroplasty. *J Am Acad Orthop Surg.* 2004;12:314–321.
29. Toomey SD, Hopper RH Jr, McAuley JP, Engh CA. Modular component exchange for treatment of recurrent dislocation of a total hip replacement in selected patients. *J Bone Joint Surg Am.* 2001;83:1529–1533.
30. Turner RS. Postoperative total hip prosthetic femoral head dislocations: incidence, etiologic factors, and management. *Clin Orthop Relat Res.* 1994;301:196–204.
31. Woo RY, Morrey BF. Dislocations after total hip arthroplasty. *J Bone Joint Surg Am.* 1982;64:1295–1306.
32. Woolson ST, Rahimtoola ZO. Risk factors for dislocation during the first 3 months after primary total hip replacement. *J Arthroplasty.* 1999;14:662–668.