Unconstrained Tripolar Implants for Primary Total Hip Arthroplasty in Patients at Risk for Dislocation

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Abstract: We performed a retrospective study on 167 primary total hip arthroplasty (THA) procedures in 163 patients at high risk for instability to assess the reliability of unconstrained tripolar implants (press-fit outer metal shell articulating a bipolar polyethylene component) in preventing dislocations. Eighty-four percent of the patients had at least 2 risk factors for dislocation. The mean follow-up length was 40.2 months. No dislocation was observed. Harris hip scores improved significantly. Six hips were revised, and no aseptic loosening of the cup was observed. The tripolar implant was extremely successful in achieving stability. However, because of the current lack of data documenting polyethylene wear at additional bearing, the routine use of tripolar implants in primary THA is discouraged and should be considered at the present time only for selected patients at high risk for dislocation and with limited activities. **Key words:** arthroplasty, tripolar hip implant, dislocation, hip, prosthesis.

Although total hip arthroplasty (THA) remains to be one of the most successful procedures in modern orthopedic surgery, complications may occur. Dislocation is one of the major complications that may lengthen patients' hospital stay and even lead to a revision arthroplasty. Functional costs are substantial for patients; in addition, the health care system is exposed to considerable extra costs. The prevalence of postoperative dislocation is highly variable. In a large literature review, Berry [1] reported on prevalence rates ranging from lower than 1% to higher than 10%. Rates between 2% and 5% have been reported for primary THA in several large series [2-5], and most dislocating events noted occurred during the first 3 months after surgery [4]. Expansion of indications for THA may be one of the possible reasons why there is no evidence that the overall prevalence of dislocation has declined in recent years despite the increasing sophistication of implants and techniques. Many arthroplasties are now performed on patients who might not have been considered as suitable candidates in earlier years when surgeons had less experience with these procedures. Many factors can explain the occurrence of instability. They can be differentiated into patient-related, implant-related, and surgery-related factors. Hip implant dislocation is well documented to be more common in specific demographic groups. Advanced age, female sex, prior hip surgery, underlying diagnosis leading to THA (eg, femoral neck fracture, avascular necrosis, hip dysplasia, and inflammatory arthritis), neuromuscular conditions that lead to muscle weakness or contractures around the hip, cognitive dysfunction, excessive alcohol consumption, and high American Society of Anesthesiologists (ASA) scores are the main patient-related risk factors reported in the literature [1,6-8].

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Table 1. Identified Patient-Related Factors for Dislocation in Primary THA

Risk Factors
Age ≥75 y
For female patients, ≥70 y
Prior hip surgery (eg, femoral or acetabular osteotomy and failed hip fracture fixation)
Underlying diagnoses (eg, femoral neck fracture, avascular necrosis of the femoral head, hip dysplasia, inflammatory arthritis, and tumor of the proximal femur)
Neuromuscular disease (eg, epilepsy, cerebral palsy, old poliomyelitis, Parkinson's disease, and myopathy)
Cognitive dysfunction (eg, dementia and Alzheimer's disease) and alcoholism
ASA score ≥3

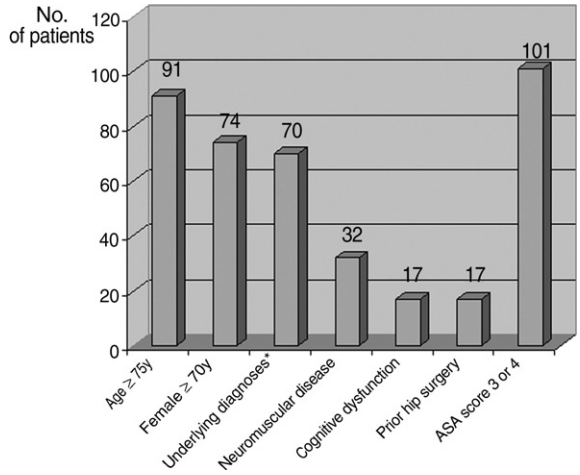

Fig. 2. Identified patient-related risk factors. *Underlying diagnoses include femoral neck fracture, avascular necrosis of the femoral head, hip dysplasia, inflammatory arthritis, and tumor at the proximal femur.

Knowledge of these patient-related factors will help surgeons preoperatively identify patients at risk for dislocation and therefore use preoperative appropriate means to prevent the occurrence of instability, including careful preoperative planning, choice of the surgical approach, and selection of the hip implant. In these patients at high risk for instability, the use of implants that provide some protection against dislocation is recommended. In Europe, the use of unconstrained tripolar implants (an outer metal shell articulating a bipolar polyethylene component) has been increasing in recent years. These implants, which provide 2 bearings, were first described by Bousquet. The original design has been altered to improve range of motion, stability, and longevity. We conducted a retrospective study to assess the reliability of primary THA using such a tripolar hip implant in patients at risk for instability, with particular attention to the postoperative dislocation rate.

Materials and Methods

We retrospectively reviewed 186 primary THAs that used an unconstrained tripolar hip implant performed between January 2000 and July 2003 in a group of 181 patients at risk for dislocation. During this period, a total of 701 primary THAs had been performed at our institution. The operations were nonconsecutive and were performed or supervised by 1 of the 2 senior surgeons at our institution (JBH and JPC). Patients were identified to be at risk for dislocation when at least one of the commonly reported patient-related risk factors was observed among them (Table 1). Of the 181 patients, 18 did not return for follow-up (19 hips), leaving 163 (167 hips) available for evaluation; these patients made up the study group. The patients included 99 women (60.7%) and 64 men (39.3%). Their mean age was 72 years (range, 21-97 years) at the time they underwent an arthroplasty. Ninety-one patients (55.8%) were aged 75 years or older, and 52 (31.9%) were aged 80 years or older (Fig. 1). Mean body mass index was 25.3 kg/m^2 for men (range, 16-39 kg/m^2) and was 24.3 kg/m^2 for women (range, 13-42 kg/m^2). Eighty-six arthroplasties had

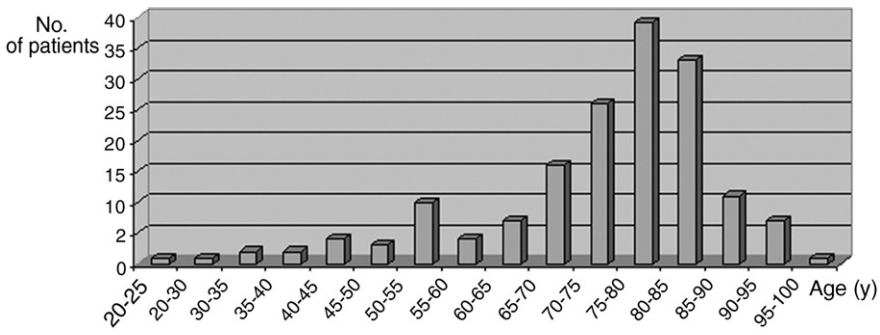

Fig. 1. Distribution of the patients with respect to age at surgery.

Table 2. Underlying Diagnoses Leading to THA

Underlying Diagnosis	Hips [*n* (%)]
Degenerative osteoarthritis	84 (50)
Posttraumatic osteoarthritis	4 (2.5)
Traumatic femoral neck fracture	23 (14)
Pathologic femoral neck fracture	5 (3)
Avascular necrosis	19 (11.5)
Hip dysplasia	9 (5.5)
Inflammatory arthritis	7 (4)
Hip arthrodesis	4 (2.5)
Tumor of the proximal femur	5 (3)
Failed hip fracture fixation	3 (2)
Paget's disease of the hip	2 (1)
Osteochondritis	1 (0.5)
Posttraumatic acetabular fracture	1 (0.5)
Total	167 (100)

been performed on the left hip, and 81 had been performed on the right. Identified risk factors (as described in Table 1) are presented in Fig. 2. Of the 163 patients, 16% had 1 risk factor, 40% had 2 risk factors, and 44% had 3 or more risk factors (Fig. 3). Clinical and radiographic data on all patients were collected prospectively. Patients were evaluated at 2 months, at 6 months, at 1 year, and annually thereafter. During the study period, 24 patients died (14.7%). All of these patients had been evaluated postoperatively, and all had well-functioning hips without dislocation at the time of their death. The mean clinical and radiographic follow-up length for the patients still alive by the end of the study period was 40.2 months (range, 24-65 months). All of these patients were followed for a minimum of 2 years. Table 2 reports underlying diagnoses at the time of the patients' hip arthroplasty.

The single-design tripolar implant used in the present series consists of a large inside-diameter stainless-steel outer shell with a highly polished inner surface that articulates an ultra–high-molecular-weight polyethylene bipolar component (Saturne, Amplitude, Porte du Grand Lyon, Neyron,

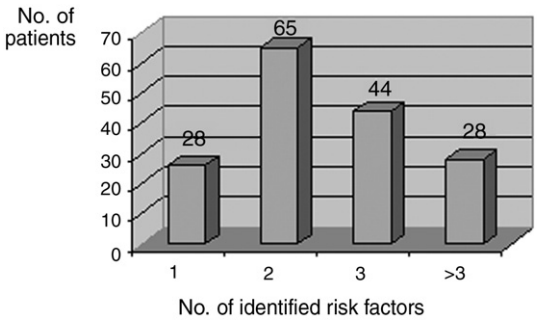

Fig. 3. Repartition of the patients with respect to number of risk factors for dislocation identified.

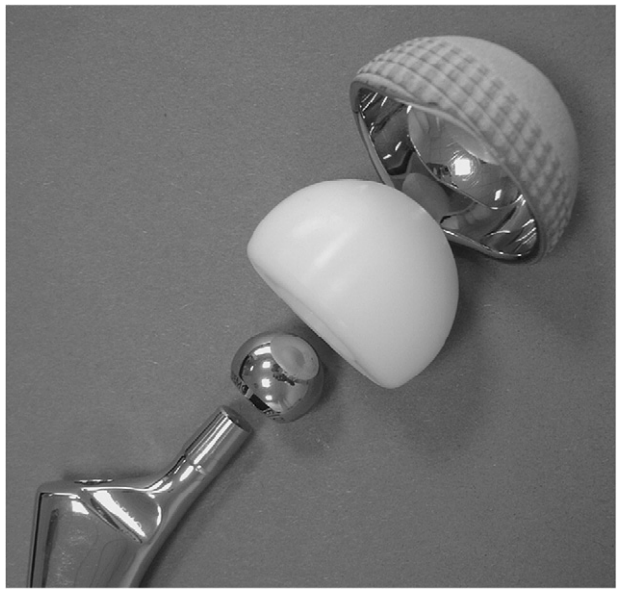

Fig. 4. Photograph of the unconstrained tripolar device showing its various components.

France; Figs. 4 and 5). The outer shell is anatomically designed and has a superior and posterior "lip" that is greater than a hemisphere and an anterior and inferior "cutout" that is smaller than a hemisphere. In constraining the femoral head, the mobile ultra–high-molecular-weight polyethylene component envelops more than 50% of the femoral head and its opening diameter is smaller than that of the femoral head. When reduced, the head is captured within the polyethylene itself (Fig. 6). The outer metal shell was press fit (hydroxyapatite plasma sprayed upon titanium coating) in 165 hips; it was cemented into a reinforcement cage in 2. A single-design femoral component was used in 157 hips (94%); it was noncemented and fully hydroxyapatite coated in

Fig. 5. Photograph of the implant assembled.

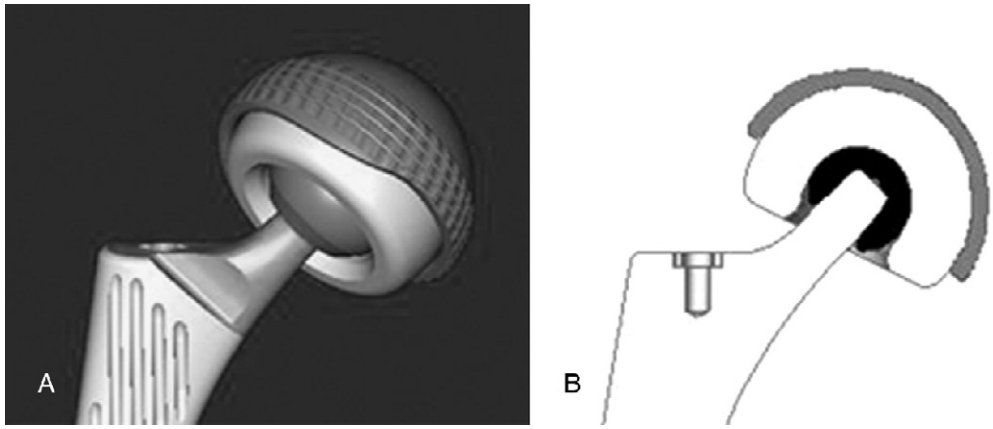

Fig. 6. The unconstrained tripolar implant. A, Assembled device; B, Section view.

147 hips and was cemented in 10. Fig. 7 shows radiographs of a typical case with the prosthesis in position. An endoprosthetic reconstruction of the proximal femur was used in 10 hips (6%), and half of them were cemented.

The arthroplasty was performed under general anesthesia in 101 hips (60%) and under spinal anesthesia in 66 (40%). The surgical approach was anterolateral in 99 hips (59%) and was posterolateral in 64 (39%). An anterolateral approach with a trochanteric osteotomy was performed in 4 hips (2%) with proximal femoral resection. Assessment of the clinical results was performed using Harris hip scores. Changes from the preoperative clinical status to the latest clinical follow-up were evaluated using the Wilcoxon signed-rank test.

Anteroposterior and lateral radiographs of the involved joint were reviewed to assess the position of the prosthesis and to look for osteolysis and signs of implant loosening. The presence of a metallic bipolar system inside the metallic shell made measurements of wear unreliable. Both cemented and noncemented acetabular components were evaluated in each of the 3 zones defined by DeLee and Charnley [9] to evaluate the location of radiolucent lines. For cemented implants, *definite loosening* was defined as migration of the component or the presence of any new fracture in the cement mantle, *probable loosening* was defined as the presence of a circumferential radiolucent line around the entire component at the bone-cement interface, and *possible loosening* was defined as the presence of a radiolucent line around 50% to 99% of the component at the bone-cement interface. Both the hydroxyapatite-coated and cemented femoral components were assessed for subsidence, and the femur was divided into 7 zones as described by Gruen et al [10] to assess radiolucent lines and osteolysis. Loosening of cemented femoral components was categorized according to the classifica-

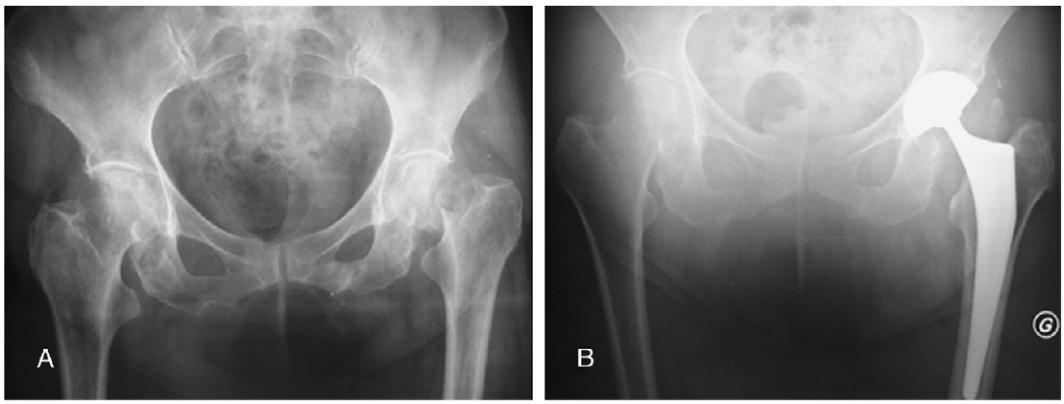

Fig. 7. Radiographs of a 79-year-old woman with left femoral neck fracture. A THA using an unconstrained tripolar implant was performed because of the high risk for dislocation in such a patient. A, Preoperative anteroposterior view; B, Postoperative radiograph with the prosthesis in position.

tion of Harris et al [11]. *Definite loosening* was defined as subsidence of the femoral component, fracture of the cement or stem, or the presence of a radiolucent line not seen on early postoperative radiographs at the prosthesis-cement interface, *probable loosening* was defined as the presence of a continuous radiolucent line along the entire bone-cement interface, and *possible loosening* was defined as the presence of a radiolucent line occupying more than 50% but less than 100% of the bone-cement interface on any radiograph or the presence of a progressive radiolucent line.

Results

During the study period, 24 patients died, 21 of whom died of unrelated causes 1 to 41 months after surgery. One patient died during surgery (proximal femur metastasis of adenocarcinoma) because of embolism secondary to the femoral component cementation. Another patient died because of a pulmonary embolism 3 days after surgery, and a third patient died 3 months after surgery secondary to an infection at the involved hip site. At the time of the most recent follow-up, no dislocation was observed and no patient experienced sensations of subluxation. The mean preoperative Harris hip score improved from 39.6 (range, 11-100) to 83.4 (range, 25-100) at the latest follow-up ($P < .05$). No acetabular component malpositioning (defined as 10° of variation from optimal positioning of the cup at 45° of lateral opening) was observed in the coronal plane. One noncemented acetabular component migrated 8 days after surgery in a 72-year-old female patient with traumatic acetabular discontinuity that had not been fixed at the time of the index arthroplasty. The treatment consisted of a revision with internal fixation and use of a cage with a cemented tripolar implant. There was no evidence of cup migration in any other patient. No radiolucent line around the hydroxyapatite-coated acetabular component and no osteolysis were observed at the latest follow-up. Three fully hydroxyapatite-coated femoral components migrated. The first component was revised 16 months after the primary procedure in a 52-year-old female patient with developmental hip dysplasia and a history of prior hip surgery. The second component, in a 60-year-old female patient with femoral head avascular necrosis and a history of kidney transplant, had not been revised at the time of the study (38 months after surgery). The third component was a femoral component subsidence of 3 mm in a 79-year-old female patient with osteoarthritis with an intraoperative calcar fracture. The evolution was favorable and no revision was required. There were 5 intraoperative fractures, including 3 acetabular fractures, 1 calcar fracture, and 1 trochanteric fracture. A nonunion of the trochanteric fracture required reoperation 7 months later. One postoperative periprosthetic fracture of the femur occurred 1 month after surgery and required open reduction, internal fixation, and femoral component exchange. Additional complications included superficial infection (3 hips), deep venous thrombosis (12 hips), pulmonary embolism (1 hip), sciatic nerve palsy (1 hip), hematoma (2 hips), and deep infection (2 hips). For 1 of the 2 deep infections, a Girdlestone procedure was elected. The other deep infection was treated with early debridement and intravenous antibiotic therapy. This treatment was unsuccessful, and the patient died 3 months later as cited.

There were 6 revisions performed for deep infections in 2 hips, aseptic loosening of the femoral component in 1 hip, periprosthetic fracture of the femur in 1 hip, posttraumatic acetabular discontinuity in 1 hip, and trochanteric nonunion in 1 hip.

Discussion

Instability after THA remains to be a troublesome complication. Identification of patients at risk for dislocation is a crucial preoperative measure in preventing the occurrence of hip instability. In the present study, we selected a group of patients who presented with at least one of the major commonly reported and recognized risk factors for dislocation. Patient-related risk factors have been well described in the literature. Women appeared to have a higher rate of dislocation as compared with men. For Woo and Morrey [12], the risk for dislocation is 2 times greater for women as compared with men; Coventry [13] observed that this rate was 3 times greater for women as compared with men 5 years after surgery. The cumulative risk for dislocation has been reported to be significantly greater for female patients (8.9%) as compared with male patients (4.5%) at 25 years ($P < .0001$) [14]. Female patients had both a higher early risk for dislocation and a higher late risk. More compliant soft tissues with greater range of motion contribute to the higher dislocation rate in women [6]. Because sex alone is not enough to indicate use of an unconstrained tripolar device, we considered female sex as a risk factor for dislocation when associated with an age of 70 years or older in the present study. Without considering sex, age at

surgery also affects the risk for dislocation. Older patients are at a higher risk as compared with younger patients. Although 2 studies failed to show any correlation between age and dislocation [15,16], Ekelund et al [17] observed a 9.2% rate of dislocation in patients older than 80 years. This rate was 3 times greater than that observed overall for the patients who underwent a THA in the same institution at that time. Newington et al [18] reported a rate of dislocation of 15.2% in primary hip arthroplasties in patients older than 80 years, and Jolles et al [7] observed a 2-fold risk for total hip replacement dislocation among octogenarians. A greater cumulative risk for dislocation when the THA was performed on patients older than 70 years has been reported [14]: the relative risk for patients who were aged 70 years or older at the time of their operation, as compared with those who were younger than 70 years, was 1.3 (95% confidence interval, 1.0-1.7). In the present study, we considered patients aged 75 years or older as patients at risk for dislocation. Advanced age has been associated with poorer soft tissues as well as greater incidence of confusion and noncompliance with dislocation precautions. Diminished proprioception and poor coordination increase the risk for falls. Previous hip surgery has been found to be a significant risk factor for instability. The dislocation rate of revision procedures is higher than that of primary procedures and is highly variable. In the case of multiple revisions, a dislocation rate as high as 26.6% has been reported [19]. A history of previous hip surgery other than hip arthroplasty is also associated with an increased risk for dislocation (osteotomy, hip fracture fixation, arthrodesis). Lindberg et al [20] reported a significantly higher risk for dislocation in hips previously operated on with osteotomy. At the Mayo Clinic, Woo and Morrey [12] reported a significantly higher dislocation rate among patients with prior surgery (4.8%) as compared with patients without prior surgery (2.4%). Muscle weakness (compromised abductor function) and bone defects (which make positioning implants more difficult) contribute to the higher risk for dislocation among previously operated patients. The underlying diagnosis leading to THA has been reported as another factor that affects the dislocation rate. Berry et al [14] identified avascular osteonecrosis of the femoral head, acute fracture or nonunion of the proximal femur, and inflammatory arthritis as underlying diagnoses with a significantly greater risk for dislocation as compared with osteoarthritis. Mallory et al [21] reported a higher risk for dislocation when THAs were performed for femoral neck fracture and congenital dislocation of the hip. Lee et al [22] reported a 10% rate of dislocation in a series of primary THAs for acute femoral neck fracture at the Mayo Clinic. Poorer or damaged muscles, greater propensity for falls, and altered proximal femoral anatomy may be contributing factors that explain the higher risk for dislocation in these diagnoses. In addition, THAs performed for tumors of the proximal femur were considered at risk for dislocation in the present study because they required a bone resection of the lesion that led to weakness of the abductor muscles at their attachment site. Some comorbid diagnoses have also been implicated to contribute to dislocation. Patients with a neuromuscular disease are at a higher risk for prosthetic hip dislocation. Fackler and Poss [2] observed a greater incidence of severe medical or neurologic problems in patients who experienced hip implant dislocation. Hedlundh et al [23] performed a matched controlled study with postural and stability tests on 65 patients. Balance and vibration sense were impaired in the patients with dislocations, as compared with patients without dislocation. Mental confusion, epilepsy, and weakness of the hip muscles caused by neurologic diseases (eg, cerebral palsy, old poliomyelitis, Parkinson's disease, and history of stroke leading to hemiplegia) are reported factors that make dislocation more likely to occur [4]. In these patients, it is difficult to determine if hip instability was caused by muscular weakness or by their lack of ability to respect dislocation precautions. In a multiple stepwise regression analysis of dislocation during the first 3 months after THA, Woolson and Rahimtoola [16] observed that mental confusion (defined as having a history of dementia or alcoholism) significantly increased the risk for instability. Lindberg et al [20] also identified alcoholism as a risk factor for dislocation. More recently, the ASA score has been identified as a good risk-for-dislocation variable because it is closely related to multisystem disease increasing with age and complicating muscle recovery [7]; the authors observed that a score of 3 or higher was a significant risk for dislocation. In the present study, 62% of the patients had an ASA score of 3 or 4. This large proportion of patients with poor underlying fitness helps explain the high incidence of deaths observed during the study period. Considering the subscribed commonly reported risk factors for dislocation, 84% of the patients in the present study had at least 2 risk factors and 44% had at least 3 risk factors. In these patients with significantly increased risk for instability, the use of implants that provide some protection against dislocation is recommended, in addition to all other measures to prevent instability. Leclercq et al [24] reported encouraging clinical

results with the use of a tripolar device during revision procedures for recurrent instability of total hip replacements. The present study was performed to evaluate the benefits of the use of a tripolar hip implant for primary THA on stability among selected patients at risk for dislocation. Results showed that the tripolar implant was extremely successful in achieving stability because no dislocation was observed among the patients. A substantial improvement in hip function was noted as well. In the literature, other options have been proposed to provide some protection against dislocation in primary procedures for patients at high risk. Cobb et al [25] reported on their experience with the use of an elevated acetabular rim liner to prevent hip instability at the primary operation. They reported a significant value of the elevated liner as compared with the standard design with respect to the 2-year probability of dislocation, particularly among patients at greatest risk. A similar trend was seen at 5 years, but the difference was not significant. However, elevated liners raise concern about the potential for increased wear and loosening resulting from impingement of the prosthetic femoral neck against the elevated rim. Such wear has been demonstrated at the time of revision of THA featuring elevated rim acetabular components [26]. The value of a larger head size to prevent prosthetic instability is getting renewed attention. Theoretically, increasing the prosthetic head diameter used with conventional implants increases stability by increasing the arc of hip motion before prosthetic impingement and the femoral head displacement necessary to cause dislocation. Thus, clinical data have not shown a strong correlation between prosthetic femoral head size and hip stability. Woo and Morrey [12] reported a 2.9% rate of dislocation in 1900 total hip replacements with a 22-mm femoral head and a 4.7% rate of dislocation in 957 total hip replacements with a 28-mm femoral head. The difference was not statistically significant. In a study on 142 dislocations among 6700 primary and revision total hip replacements, Ali Khan et al [4] reported no difference in rates of dislocation among 5 femoral implants using diameter heads of 22, 26, 28, and 32 mm. Ritter [27] reported a dislocation rate of 5% in 143 arthroplasties with 32-mm femoral heads and that of 9% with 22-mm femoral heads. Again, this difference was not statistically significant. Hedlundh et al [28] compared the dislocation rates of total hip replacements using in one group 22-mm femoral heads and in another group 32-mm femoral heads. The small femoral head was not associated with an increased risk for dislocation. This result is in agreement with the results reported by Woo and Morrey [12], who reported no greater stability for the 32-mm head as compared with the 22-mm head. Unlike these retrospective studies, the prospective randomized study by Kelley et al [29] reported an increased rate of dislocation with a 22-mm femoral head as compared with a 28-mm femoral head. However, the head size itself was not the only variable that affected stability. The 22-mm head was shown to be markedly more unstable when the outside diameter of the acetabulum was greater than 56 mm as compared with smaller-diameter cups. Crowninshield et al [30] showed that increasing the prosthetic femoral head size from 22 to 40 mm improved stability because it increased the required displacement for dislocation by approximately 5 mm with the acetabular component at 45° of lateral opening. However, they also showed that the stability provided by larger prosthetic femoral heads was substantially dependent on the orientation of the acetabular implant. An increase of the cup abduction greatly diminished this stability advantage of larger prosthetic femoral heads. Large femoral head sizes have a major disadvantage with respect to polyethylene wear. Kabo et al [31] reported an increase of the volumetric wear with larger prosthetic head sizes. However, the use of larger femoral component heads has recently become more popular as alternate bearings improved. Highly cross-linked polyethylene has been reported to improve wear resistance in laboratory testing [32,33]. The availability of the highly cross-linked polyethylene enabled surgeons to expand the use of big femoral heads in primary THA in preventing dislocation. Besides the metal-on-polyethylene bearing, metal-on-metal hip systems have reemerged over the past decade and have allowed for the use of larger femoral heads, although metal-on-metal bearing raised concern because of local metallosis and potential toxic effects caused by metallic debris dissemination. Ceramic bearings also enable surgeons to use larger femoral heads. The cost of these alternate bearings is substantial and has to be weighed against patient benefit. With larger prosthetic heads, the diversity in bearing materials or femoral head types should not affect the results on stability because all the devices behave similarly with respect to bone-to-bone or component-to-component impingement. Using femoral heads greater than 36 mm with metal-on-metal and metal-on–cross-linked polyethylene bearings, Amstutz et al [34] reported a prevalence of dislocation of 4% in 57 primary THAs. They did not mention whether patients were at higher risk for dislocation.

The use of bipolar implants has also been reported as another option to prevent total hip replacement instability. Bipolar hemiarthroplasties have been reported with a lower rate of dislocation as compared with conventional THAs. Barnes et al [35] reported a dislocation rate of 1.5% for 1934 bipolar hemiarthroplasties performed on 1765 patients at 2 institutions. The main underlying diagnosis was femoral neck fracture, which was shown to have an increased risk for dislocation. However, these encouraging results with the use of bipolar implants to prevent the occurrence of dislocation must be balanced with potentially poor functional results. For most patients with hip osteoarthritis, resurfacing of the acetabulum with a fixed socket is preferred to optimize clinical results and pain relief. Parvizi and Morrey [36] reported successful results on stability with the use of bipolar implants in 93% of their patients with recurrent prosthetic instability, but 66% complained of hip pain and 26% underwent reoperation with conversion to a THA.

Constrained acetabular components have the advantage of a capture mechanism preventing dislocation. The use of such implants to treat recurrent instability is increasing as good short-term results have revealed success in more than 90% of cases [37-39]. However, the effectiveness is design dependent and early failure mechanisms of constrained implants have been reported [40-44]. In their series, Goetz et al [37] expanded the use of a constrained implant in primary procedures in 4 patients at high risk for dislocation. Two patients had polio residuals, and the other 2 were elderly patients with senile dementia and confusion who sustained intertrochanteric fractures on the side of a previously symptomatic degenerative hip. The minimum length of follow-up was 2 years, and successful results were achieved regarding stability. Other authors proposed the use of constrained liners in primary procedures to prevent dislocation in patients at high risk for dislocation because of dementia, deficient musculature, and poor muscle control [45]. However, these implants raise concerns related to the decreased range of motion, potential for impingement, and increased interfacial stresses that may predispose these hips to increased risks for wear, osteolysis, and loosening. In a relatively short-term study (mean duration of radiographic follow-up of 2.9 years) on 110 THAs using a constrained acetabular implant, Shrader et al [46] reported a 14% rate of radiolucent lines around the acetabular component. They discouraged the routine use of these components for instability and considered these components as salvage procedures instruments for unstable hips for which multiple prior surgical attempts at stabilization had failed. The use of such implants might be restricted to elderly low-demand patients.

There are very few data on the use of tripolar implants for primary procedures published in the literature. Regarding the dislocation rate, the results of the present study are consistent with those reported in the literature with the use of the original design of tripolar implants proposed by Bousquet. However, unlike the present study, the published series did not include patients at particular risk for dislocation. Farizon et al [47] reported the results of 144 tripolar cups consecutively implanted to treat nontraumatic hip disorders. The mean age of the patients was 63 years, and the authors reported on one case of recurrent dislocation caused by a retroverted cup that required a revision during the second postoperative year. Aubriot et al [48] also showed successful results at a mean follow-up length of 5 years after implantation of a tripolar hip implant in 100 patients primarily with osteoarthritis. The mean age of the patients was only 54.1 years at the time of surgery, and no dislocation occurred before the fifth postoperative year. However, both subscribed studies reported on one case of dislocation that occurred between the femoral head and the polyethylene mobile component 10 and 5.5 years, respectively, after the THA was performed. Other cases of such a so-called intraprosthetic dislocation have been reported [49]. All occurred at an average of 10 years after surgery. This complication was more likely to occur when femoral components with a large neck diameter ($\geq$12/14 Morse taper) and a small prosthetic femoral head size (22.2 mm) were used in association with the original design of the tripolar implant described by Bousquet. Such a dislocation (that occurred secondary to cold-flow failure and wear of the capturing area of the polyethylene component) depended on the thickness of the polyethylene component. Impingement of the prosthetic femoral neck against the chamfer of the mobile polyethylene component is responsible for this failure and is typically a medium- to long-term complication of the original tripolar design. In the present study, a single-design tripolar cup and femoral component (137° neck-shaft angle and 10/12 Morse taper) was used for all the patients, except for cases of endoprosthetic reconstruction of the proximal femur (6% of the patients). The design of the tripolar implant used has been altered not only to improve range of motion and stability but also to optimize the geometry of the neck-chamfer area to reduce the risk for polyethylene wear. The neck of the femoral component is highly polished to reduce abrasive

wear at the chamfer of the polyethylene component. However, longer follow-up is required to evaluate the effects of this altered tripolar implant design on the occurrence of intraprosthetic dislocation. Unlike with constrained implants, concerns about increased interfacial stresses and risk for loosening were not observed in the present study with tripolar implants. Except for one case of cup migration related to a technical error that occurred 8 days after the index procedure (in a patient with a traumatic acetabular discontinuity that had not been fixed initially), no aseptic loosening of the tripolar cup was observed. Although the follow-up was limited, this result is in agreement with that of Farizon et al [47], who demonstrated encouraging long-term results with alumina-coated press-fit tripolar cups. However, the tripolar implant raises concern about the wear of the polyethylene component at the 2 bearing surfaces, particularly at the convexity of the outer bearing. The theoretical sequence of motion has been reported in an in vitro laboratory study [50]: preferentially, the motion took place at the inner bearing and was observed at the outer bearing at the extremes of motion. If a comparable pattern occurs in vivo, limited polyethylene wear at the outer bearing could be expected. However, because of the current lack of scientific data regarding polyethylene wear in such a device, we do not recommend the routine use of tripolar implants in primary THA, particularly for young and/or active patients. At the present time, tripolar implants should be considered for primary THA only in patients at high risk for dislocation and with limited levels of activity or poor life expectancy. At our institution, the use of such implants represents 27% of the implants used for primary THA. In such a device, the use of a 22-mm prosthetic femoral head is recommended because it allows for the preservation of the polyethylene thickness while providing the same global range of motion as that with a 28-mm prosthetic femoral head [51,52]. In these situations with high risk for dislocation, these implants provide encouraging early results, albeit the long-term results of polyethylene wear are not known at the present time.

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