Is the Dislocation Rate Higher after Bipolar Hemiarthroplasty in Patients with Neuromuscular Diseases?

Kuen Tak Suh MD, Dae Woong Kim MD,
Hong Seok Lee MD, Yoon Jae Seong MD,
Jung Sub Lee MD

Received: 16 March 2011 / Accepted: 6 October 2011 / Published online: 21 October 2011
© The Association of Bone and Joint Surgeons® 2011

Abstract

Background Patients with neuromuscular disease reportedly have a higher incidence of postoperative dislocation after bipolar hemiarthroplasty. Although the literature has focused on a high prevalence of preoperative neurologic conditions in patients who had dislocations after bipolar hemiarthroplasties, the relative incidence of dislocation in patients with neuromuscular disease and without is unclear. **Questions/purposes** We therefore (1) asked whether the incidence of postoperative dislocation after bipolar hemiarthroplasty was greater in patients with neuromuscular disease than for those without, and (2) whether function differed between the two groups, and (3) explored potential risk factors for dislocation in two groups.

Each author certifies that he has no commercial association (eg, consultancies, stock ownership, equity interest, patent, licensing arrangements, etc) that might pose a conflict of interest in connection with the submitted article.

Clinical Orthopaedics and Related Research neither advocates nor endorses the use of any treatment, drug, or device. Readers are encouraged to always seek additional information, including FDA-approval status, of any drug or device prior to clinical use. All ICMJE Conflict of Interest Forms for authors and *Clinical Orthopaedics and Related Research* editors and board members are on file with the publication and can be viewed on request. Each author certifies that his institution has approved the human use protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for clinical participation in the study was obtained.

K. T. Suh (✉), D. W. Kim, H. S. Lee, Y. J. Seong, J. S. Lee
Department of Orthopaedic Surgery, Pusan National University
School of Medicine, Beomeo-ri, Mulgeum-eup,
Yongsan 626-770, Korea
e-mail: kuentak@pusan.ac.kr

Methods We retrospectively reviewed 190 patients who underwent bipolar hemiarthroplasties for fracture of the femoral neck between 1996 and 2008. Of the 190 patients, 42 had various neuromuscular diseases and 148 had no history of neuromuscular disease. Intraoperative stability was tested and posterior soft tissue repair was performed in all patients. We determined the incidence of dislocation, postoperative leg length discrepancy, and femoral offset in patients with or without neuromuscular disease.

Results The incidence of dislocation was 2.6% in all patients. We observed similar rates of dislocation in the two groups: 4.8% (two of 42 hips) in patients with neuromuscular disease and 2.0% (three of 148 hips) in patients without neuromuscular disease.

Conclusions In femoral neck fractures in patients with neuromuscular disease, careful preoperative management and operative technique such as a posterior soft tissue repair might decrease the risk of postoperative dislocation; therefore, we consider the bipolar hemiarthroplasty a reasonable treatment option.

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

Introduction

Many patients with neuromuscular disease eventually require hip arthroplasty either because of the development of hip dysplasia with secondary degenerative joint disease (eg, cerebral palsy) or primary degenerative joint disease independently of the neurologic condition (eg, Parkinson's disease) or femoral neck fractures. Neuromuscular conditions can be divided into two categories: one accompanied

by decreased muscle tone and the other associated with increased muscle tone and contractures or movement disorders. The former includes conditions such as poliomyelitis and Down syndrome, and the latter includes conditions such as cerebral palsy, Parkinson's disease, and stroke [7]. Neurologic conditions affecting the hip pose a particular challenge for the arthroplasty surgeon, with associated paresis, spasticity, contractures, and tremors potentially leading to poor or imbalanced muscle tone across the hip [7, 23].

Evidence also suggests patients with neuromuscular disease are at increased risk of falls [4, 7, 32], which is related more to intrinsic than extrinsic factors [4, 18]. Patients with neuromuscular diseases also apparently have increased rates of osteoporosis that might not be related solely to immobility [7, 17]. With increased risks for falls and osteoporosis, patients with neuromuscular diseases may be at an increased risk of fracture of the femoral neck.

Treatment options for displaced femoral neck fractures in elderly patients include internal fixation, monopolar hemiarthroplasty (HA), bipolar HA, and THA. Many surgeons prefer bipolar HA [1, 2, 5, 13, 15, 25]. Iorio et al. [15] suggested bipolar HA is the most cost-effective treatment option for displaced femoral neck fractures in the elderly. Haidukewych et al. [13] reported high component survivorship (95.1% at 5 years, 93.6% at 10 years, and 89.2% at 15 years) and a low dislocation rate (1.9%) after bipolar HA for displaced femoral neck fractures in elderly patients. However, high death rates (14%–47% [9, 11, 31]) and postoperative complication rates (32%–87% [11, 31]) have been reported after surgically treating patients who had neuromuscular disease, particularly after the treatment of fractures about the hip [3, 9, 10, 12]. Some studies suggest these patients have high rates of dislocation ranging from 10.6% to 45% [9, 25, 31], and decubitus ulcers ranging from 6% to 49% [9, 25, 31]. These studies identified various reasons for dislocation including trauma, fall, component malposition, inner bearing dissociation, and breakage behind such events; one suggested potential ways to prevent such dislocation (eg, protective measures, prophylactic use of hip brace during the first few weeks after surgery) [8]. Three studies [9, 25, 31] focused on a high incidence of preoperative neurologic conditions in patients who had dislocations after the bipolar HA, but did not clarify the relative incidence of dislocation in patients with neuromuscular diseases and without.

We therefore (1) asked whether the incidence of postoperative dislocation after bipolar HA was greater in patients with neuromuscular disease than in those without, and (2) whether function differed between the two groups, and (3) explored potential risk factors for dislocation in two groups.

Patients and Methods

We retrospectively reviewed the charts and radiographs of 190 patients who underwent bipolar HAs for unilateral fractures of the femoral neck between 1996 and 2008. Of the 190 patients, 42 had various neuromuscular diseases including cerebral infarction, Parkinsonism, poliomyelitis, and dementia (Group I), and 148 had no neuromuscular disease (Group II). We excluded patients with a history of hip surgery or pathologic fracture caused by tumor. Patients who had fractures of the limb involved with neuromuscular disease were assigned to Group I. Of the 190 patients, 122 were females and 68 were males. The minimum followup was 13 months (mean, 36.5 months; range, 13–76 months). No patients were lost to followup. The study protocol was approved by our local Institutional Review Board, and informed consent to participate in medical research was obtained from all patients.

There were no differences between the two groups regarding demographic characteristics (Table 1). The acetabular and head distribution also did not differ between two groups. The 42 patients in Group I had cerebral infarction ($n = 24$), dementia ($n = 8$), Parkinsonism ($n = 7$), and poliomyelitis ($n = 3$) (Table 2).

We performed careful preoperative templating to adjust limb length and femoral offset to the level of the

Table 1. Demographic characteristics of the two groups

Characteristics	Group I	Group II	p value
Number of patients	42	148	
Sex			0.474
Male	17 (40%)	51 (34%)	
Female	25 (60%)	97 (66%)	
Age (years)*	76 (54–91)	77 (58–93)	0.186
Followup (months)*	35 (13–67)	38 (15–76)	0.754
Diameter of acetabular shell (mm)*	46.3 (41–55)	46.4 (40–55)	0.573
Diameter of femoral head (mm)*	27.0 (22–28)	27.4 (22–28)	0.423

* Values are given as means, with ranges in parentheses.

Table 2. Underlying disease in patients with neuromuscular disease

Underlying disease	Number of patients ($n = 42$)	Dislocation
Cerebral infarction	24	1
Dementia	8	0
Parkinsonism	7	1
Poliomyelitis	3	0

Fig. 1A–B The radiographs show (A) selection of the appropriate bipolar cup size and marking the bipolar center of rotation and (B) determination of the conventional level of femoral neck resection.

nonfractured side (Fig. 1) [28]. The underlying neuromuscular disease of each patient was controlled with medication. All patients received preoperative antibiotics to prevent postoperative infection, and an antiembolic stocking.

Bipolar HA was performed using the posterolateral approach with enhanced soft tissue repair, with the patients in the lateral decubitus position [29]. The same surgeon (KTS) performed all surgeries in all patients. Neck cutting according to the preoperative template was done. The femoral canal was prepared by removing all loose cancellous bone and drying the canal. A plastic plug was placed distally, and vacuum-mixed cement (Simplex P®; Howmedica, Rutherford, NJ, USA) was introduced in a retrograde manner with a cement gun into the femoral canal before insertion of the stem. The acetabular components were inserted without reaming of the acetabulum. We performed intraoperative stability and hip traction tests to check stability and soft tissue tension. ROM during the intraoperative stability test was assessed with the trial components in place. Full extension with 40° external rotation and flexion to 90° with at least 45° internal rotation was desirable for stability of the joint. One design of cemented femoral component (Versys® Cemented CT; Zimmer Inc, Warsaw, IN, USA) was used for the bipolar HAs. Prosthetic femoral head sizes of 22 and 28 mm were available in our country, and this implant system offered five choices of length, of which the first three do not have a skirt or extension. All bipolar acetabular components had a mobile inner polyethylene liner in a cobalt-chromium metal shell (Multipolar; Zimmer). We used the posterior soft tissue repair technique [29], which attaches the articular capsule and conjoint tendon to the greater trochanter, in all patients to regain soft tissue tension. During the posterolateral approach, the piriformis and conjoint tendon including the obturator internus were detached with electrocautery as close as possible from their insertion to obtain a wide flap. A nonabsorbable suture was passed through the tendinous portion of the piriformis muscle as a

mattress suture, and the piriformis then was retracted posteromedially. The same procedure was repeated for the conjoint tendon. After reflecting these muscles, the posterior capsule was exposed along the base of the neck. Using electrocautery, the capsule was incised along the base of the neck. This capsulotomy was continued posterosuperiorly and posteroinferiorly to the acetabular labrum. A trapezoidal posteriorly broad-based capsular flap was created. Nonabsorbable mattress sutures were passed through the superior and inferior margins of the capsular flap and the capsular flap then was reflected in one piece. After completing the bipolar HA, two drill holes 2 to 3 cm apart were made in the greater trochanter from the anterior to the posterior direction. Two loops of nonabsorbable sutures in the upper end of the capsule and the piriformis were passed through the upper hole. The same procedure was repeated for the lower portion. Two loops of nonabsorbable sutures in the posterior capsule were tied tightly with the leg in external rotation. The same procedure was repeated on the short external rotators. The loops of the capsule and the short external rotators were tied separately to obtain a tightening effect because one of the loops could become loosened if tied in one piece.

Postoperatively, we used a triangular pillow to maintain abduction and prevent extremes of flexion. Patients remained at bed rest on the first day, followed by partial weightbearing with crutches for 6 weeks, and progressing to full weightbearing as tolerated. They were taught precautions against dislocation, and these were reinforced by the doctor before the patients were discharged from the hospital, which was usually on the tenth to fourteenth postoperative day. The patients were given an elevated toilet seat, and they were advised to limit flexion to 90° for the first 6 weeks after the operation.

Patients were followed clinically and radiographically at 6 weeks, 6 months, 12 months, and annually thereafter from surgery. We obtained postoperative Harris hip scores. At routine followups, AP, lateral, and crosstable lateral radiographs of the hip were obtained.

An orthopaedic fellow (HSL) blinded to the clinical results and not involved in surgery measured the hip center of rotation, femoral offset, and limb length preoperatively on AP radiographs of both hips (Fig. 1) [28]. These parameters then were remeasured on radiographs made at the immediate postoperative evaluation. Incidence of dislocation in both groups was compared, and limb length discrepancy and femoral offset of both groups also were measured with the postoperative AP radiograph. True limb length discrepancy was gained by calculating the relative rate of the real bipolar cup. Magnification was determined by using known dimensions of the bipolar cup. The postoperative leg length measurement was performed by measuring the distance between the base of the teardrop of the acetabulum and the top of the lesser trochanters in both hips. Femoral offset was measured as the horizontal distance from a line drawn from the center of the femoral diaphysis to the center of rotation of the femoral head. The femoral offset, which represents the perpendicular distance from the femoral axis to the bipolar center of rotation, then was compared with the offset for the normal contralateral hip.

We analyzed the following factors to determine whether they had had any influence on the rate of dislocation: demographic factors included age, sex, bipolar acetabular component diameter, femoral head diameter, and preoperative underlying neuromuscular disease, and operative factors included limb length discrepancy and horizontal offset. Age, duration of followup, limb length discrepancy, and femoral offset were analyzed using independent t-test, sex using chi square test, and incidence of dislocation using Fisher's exact test. Logistic regression analysis was performed to evaluate independent association of risk factors with the incidence of dislocation in both groups. Statistical analysis was performed with SPSS[®] Version 14.0 software (SPSS Inc, Chicago, IL, USA).

Results

We observed similar ($p = 0.330$) incidences of dislocation in both groups: 4.8% (two of 42) in Group I and 2.0% (three of 148) in Group II (Table 3). The incidence of dislocation was 2.6% (five of 190) for all patients. Dislocations occurred at 2 and 8 weeks after surgery in Group I patients and at 1, 3, and 10 weeks after surgery in Group II patients. Five patients with dislocations underwent manual reduction after the muscles were relaxed adequately by general anesthesia. The manual reductions were successful and without complications, including bipolar HA dissociation (Fig. 2). An abduction brace was applied for 6 weeks to prevent redislocation, and none has occurred. Five patients were followed up to 13, 15, 17, 19, and 25 months

Table 3. Clinical and radiographic data for the two groups

Parameter	Group I (n = 42)	Group II (n = 148)	p value
Number of dislocations (%)	2 (4.8)	3 (2.0)	0.330
Leg length discrepancy (mm)*	-1.7 (-2.86-3.38)	-0.7 (-4.53-4.51)	0.586
Horizontal offset (mm)*	2.3 (-3.15-4.28)	1.6 (-4.12-5.48)	0.762

* Values are given as means, with ranges in parentheses.

after dislocation, respectively. Patients in Group I who experienced dislocations had cerebral infarction ($n = 1$) and Parkinsonism ($n = 1$) (Table 2). Postoperative limb length discrepancies were -1.7 mm (range, -2.86-3.38 mm) in Group I and -0.7 mm (range, -4.53-4.51 mm) in Group II ($p = 0.586$). Postoperative femoral offsets were 2.3 mm (range, -3.15-4.28 mm) in Group I and 1.6 mm (range, -4.12-5.48 mm) in Group II ($p = 0.762$). There were no differences in leg length discrepancy and horizontal offset between the groups (Table 3).

The average Harris hip score was 93 points (range, 85-99 points) at the final examination. The initial dislocation occurred at a mean of 4.8 weeks (range, 1-10 weeks) after the five bipolar HAs (Table 4).

We observed no independent association of risk factor with the incidence of dislocation in our two groups of patients (Table 5).

Discussion

Patients with neuromuscular diseases reportedly have a greater incidence of postoperative dislocation after bipolar HA than those without [25]. Previous studies [9, 25, 31] have focused on a high prevalence of preoperative neurologic conditions in patients who had dislocations after the bipolar HA but have not clarified the relative incidence of dislocation in patients with neuromuscular disease and without. We therefore asked whether the incidence of postoperative dislocation after bipolar HA was greater in patients with neuromuscular disease than in those without and whether function differed between the two groups, and explored potential risk factors for dislocation in two groups of patients.

We recognize limitations to our study. First, this was a retrospective study with relatively small cohorts with short-term followup. Long-term results of a large group of patients are necessary to determine if the incidence of dislocation in patients with neuromuscular diseases is

Fig. 2A–D Prereduction (A) AP and (B) lateral radiographs show dislocation of the bipolar hemiarthroplasty. The patient's postreduction (C) AP and (D) lateral radiographs show successful closed reduction.

Table 4. Data for patients with dislocated bipolar prostheses

Patient	Age at surgery (years)	Group	Time to dislocation (weeks)	Mechanism of dislocation	Direction of dislocation (radiograph)	Initial treatment	Final treatment and outcome	Followup duration after dislocation (months)
1	80	I	2	Fall	Posterior	Closed reduction	No redislocation	15
2	70	I	8	Fall	Posterior	Closed reduction	No redislocation	13
3	68	II	1	Atraumatic	Posterior	Closed reduction	No redislocation	25
4	73	II	3	Atraumatic	Anterior	Closed reduction	No redislocation	19
5	76	II	10	Atraumatic	Posterior	Closed reduction	No redislocation	17

Table 5. The analysis of risk factors for dislocation

Factor	Odds ratio	p value
Age	0.920	0.261
Followup duration	0.977	0.999
Limb length discrepancy	0.856	0.624
Femoral offset	0.895	0.644

greater than for patients without neuromuscular diseases. Second, we did not directly compare our findings with a cohort study without careful preoperative management and operative technique such as a posterior soft tissue repair. Prospective studies or large retrospective studies would be required to determine the effects of surgical factors such as soft tissue repairs.

We found a total incidence of dislocation of 2.6% (five of 190). Among these 190 patients, the incidence of

dislocation was 4.8% (two of 42) in the group with neuromuscular disease and 2.0% (three of 148) in the group without neuromuscular disease. Several studies have documented the rate of dislocation after bipolar HA in patients with neuromuscular diseases (Table 6) [9, 25, 31]. Dislocation of a bipolar HA is uncommon, with reported rates of 1.5% to 2.0% [1, 3, 13, 25]. Bipolar HA is used as a treatment for recurrent dislocation after THA owing to its dynamic stability. The largest published series to date, combining data from two institutions, reported a 1.5% incidence of dislocation in bipolar arthroplasties during a 17-year period [1]. Another study, in which dislocation rates between early bipolar prostheses were compared, had prevalence rates ranging from 2.8% to 13.4% in prostheses inserted from 1977 to 1984 [24]. The factors contributing to dislocation in patients who had bipolar HAs are not well known. A history of hip surgery, inadequate soft tissue tension, method of surgical approach, and preoperative

Table 6. Review of literature on dislocation after bipolar HA in patients with neuromuscular disease

Study	Rate of dislocation	Approach in patients with dislocation	Initial treatment
Coughlin and Templeton [9]	37% (18/49)	Posterior	
Sierra et al. [25]	45% (11/24)		Closed and open reduction
Turcotte et al. [31]	10.6% (5/47)	Posterolateral	Closed reduction
Current study	4.8% (2/42)	Posterior	Closed reduction

HA = hemiarthroplasty.

diagnosis are known risk factors for dislocation [1, 6, 20, 25, 32]; it is known that patients with neuromuscular diseases have a greater incidence of postoperative dislocations after THA [9, 25, 31]. Once the dislocation has occurred, complications and morbidity related to difficulty in manual reduction, chances of open reduction, and replacement of prostheses increase [2, 12, 22, 25, 27]. Thus, prevention is more important than treatment.

We performed careful preoperative planning, postoperative precautions designed to prevent dislocation, intraoperative stability testing, and used a posterior soft tissue repair technique [29] that helps maintain adequate soft tissue tension to decrease the risk for postoperative dislocation in patients with neuromuscular diseases. Special effort is required to prevent intraoperative and postoperative dislocations as stability is a concern for patients with neuromuscular disease who have THAs [7]. Sierra et al. [25] reported a high incidence of dislocation after bipolar HAs in patients with neuromuscular disease. Cognitive dysfunction from confusion, dementia, psychosis, or alcoholism is a reported risk factor for hip instability [21, 33]. Woolson and Rahimtoola [33] used regression analysis of dislocation in the first 3 months postoperatively and found cognitive dysfunction was a major factor. Neuromuscular dysfunction has a positive association with dislocation [14, 21]. In addition, lack of compliance with postoperative instructions can lead to improper positioning of the limb and inadequate myofascial tension can lead to instability of the hip. Trauma to the hip, such as a fall or slip, can cause a sudden dislocation of an optimally positioned total hip prosthesis [21]. The mechanism leading to dislocation in our group of patients might be because of muscle imbalance, with increased muscle tone and rigidity seen with Parkinson's disease, or cognitive dysfunction that reduces the patient's ability to comply with precautions designed to prevent dislocation. We believe patients with these neurologic impairments should be treated with additional preventive measures to decrease the chance of postoperative dislocation.

Some authors consider the posterior approach a risk factor for dislocation after bipolar HA [6, 20, 32]. Paton and Hirst [22] reported on Monk and Charnley-Hastings bipolar arthroplasties in 63 hips and found a dislocation

rate of 4.8%. No dislocations occurred when using a direct lateral approach, although three of 36 occurred when using a posterior approach [22]. Sierra et al. [25] reported surgical approach and dislocation do not correlate after 20 years followup of 1812 bipolar HAs, and Ko et al. [18] reported a dislocation rate of 1.9% using a posterior soft tissue repair technique in bilateral bipolar HAs. Barnes et al. [1] reported no difference in dislocation rates between surgical approaches for bipolar HAs. The reported dislocation rate after THA using the posterior approach with adequate soft tissue repair is not high [16, 19, 26, 29, 30]. Because we used the posterior approach in all patients, comparison with another approach is needed.

We found no difference in the incidence of dislocation between patients with or without neuromuscular disease by maintaining adequate soft tissue tension using a posterior soft tissue repair technique. We believe the incidence of dislocations after bipolar HAs for patients with neuromuscular diseases can be decreased by careful preoperative planning, precautions designed to prevent dislocation, intraoperative stability testing, and a posterior soft tissue repair technique that helps to maintain adequate soft tissue tension.

References

1. Barnes CL, Berry DJ, Sledge CB. Dislocation after bipolar hemiarthroplasty of the hip. *J Arthroplasty*. 1995;10:667–669.
2. Bhuller GS. Use of Giliberty bipolar endoprosthesis in femoral neck fractures. *Clin Orthop Relat Res*. 1982;162:165–169.
3. Blewett N, Mortimore S. Outcome of dislocation after hemiarthroplasty for fractured neck of the femur. *Injury*. 1992;23:320–322.
4. Bloem BR, Grimbergen YA, Cramer M, Willemsen M, Zwiderman AH. Prospective assessment of falls in Parkinson's disease. *J Neurol*. 2001;248:950–958.
5. Bochner RM, Pellicci PM, Lyden JP. Bipolar hemiarthroplasty for fracture of the femoral neck: clinical review with special emphasis on prosthetic motion. *J Bone Joint Surg Am*. 1988;70:1001–1010.
6. Bush JB, Wilson MR. Dislocation after hip hemiarthroplasty: anterior versus posterior capsular approach. *Orthopedics*. 2007;30:138–144.
7. Cabanela ME, Weber M. Total hip arthroplasty in patients with neuromuscular disease. *Instr Course Lect*. 2000;49:163–168.

8. Clubb VJ, Clubb SE, Buckley S. Parkinson's disease patients who fracture their neck of femur: a review of outcome data. *Injury*. 2006;37:929–934.
9. Coughlin L, Templeton J. Hip fractures in patients with Parkinson's disease. *Clin Orthop Relat Res*. 1980;148:192–195.
10. Eiskjaer S, Ostgard SE. Risk factors influencing mortality after bipolar hemiarthroplasty in the treatment of fracture of the femoral neck. *Clin Orthop Relat Res*. 1991;270:295–300.
11. Eventov I, Moreno M, Geller E, Tardiman R, Salama R. Hip fractures in patients with Parkinson's syndrome. *J Trauma*. 1983;23:98–101.
12. Georgiou G, Siapkara A, Dimitrakopoulou A, Provelengios S, Dounis E. Dissociation of bipolar hemiarthroplasty of the hip after dislocation: a report of five different cases and review of literature. *Injury*. 2006;37:162–168.
13. Haidukewych GJ, Israel TA, Berry DJ. Long-term survivorship of cemented bipolar hemiarthroplasty for fracture of the femoral neck. *Clin Orthop Relat Res*. 2002;403:118–126.
14. Hedlundh U, Karlsson M, Ringsberg K, Besjakov J, Fredin H. Muscular and neurologic function in patients with recurrent dislocation after total hip arthroplasty: a matched controlled study of 65 patients using dual-energy X-ray absorptiometry and postural stability tests. *J Arthroplasty*. 1999;14:319–325.
15. Iorio R, Healy WL, Lemos DW, Appleby D, Lucchesi CA, Saleh KJ. Displaced femoral neck fractures in the elderly: outcomes and cost effectiveness. *Clin Orthop Relat Res*. 2001;383:229–242.
16. Iorio R, Specht LM, Healy WL, Tilzey JF, Presutti AH. The effect of EPSTR and minimal incision surgery on dislocation after THA. *Clin Orthop Relat Res*. 2006;447:39–42.
17. Kao CH, Chen CC, Wang SJ, Chia LG, Yeh SH. Bone mineral density in patients with Parkinson's disease measured by dual photon absorptiometry. *Nucl Med Commun*. 1994;15:173–177.
18. Ko CK, Law SW, Chiu KH. Enhanced soft tissue repair using locking loop stitch after posterior approach for hip hemiarthroplasty. *J Arthroplasty*. 2001;16:207–211.
19. Kwon MS, Kuskowski M, Mulhall KJ, Macaulay W, Brown TE, Saleh KJ. Does surgical approach affect total hip arthroplasty dislocation rates? *Clin Orthop Relat Res*. 2006;447:34–38.
20. Pajarinen J, Savolainen V, Tulikoura I, Lindahl J, Hirvensalo E. Factors predisposing to dislocation of the Thompson hemiarthroplasty: 22 dislocations in 338 patients. *Acta Orthop Scand*. 2003;74:45–48.
21. 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.
22. Paton RW, Hirst P. Hemiarthroplasty of the hip and dislocation. *Injury*. 1989;20:167–169.
23. Queally JM, Abdulkarim A, Mulhall KJ. Total hip replacement in patients with neurological conditions. *J Bone Joint Surg Br*. 2009;91:1267–1273.
24. Rao JP, Vernoy TA, Allegra MP, DiPaolo D. A comparative analysis of Giliberty, Bateman, and Universal femoral head prostheses: a long-term follow-up evaluation. *Clin Orthop Relat Res*. 1991;268:188–196.
25. Sierra RJ, Schleck CD, Cabanela ME. Dislocation of bipolar hemiarthroplasty: rate, contributing factors, and outcome. *Clin Orthop Relat Res*. 2006;442:230–238.
26. Sioen W, Simon JP, Labey L, Van Audekercke R. Posterior transosseous capsulotendinous repair in total hip arthroplasty: a cadaver study. *J Bone Joint Surg Am*. 2002;84:1793–1798.
27. Star MJ, Colwell CW Jr, Donaldson WF 3rd, Walker RH. Dissociation of modular hip arthroplasty components after dislocation: a report of three cases at differing dissociation levels. *Clin Orthop Relat Res*. 1992;278:111–115.
28. Suh KT, Moon KP, Lee HS, Lee CK, Lee JS. Consideration of the femoral head cartilage thickness in preoperative planning in bipolar hemiarthroplasty. *Arch Orthop Trauma Surg*. 2009;129:1309–1315.
29. Suh KT, Park BG, Choi YJ. A posterior approach to primary total hip arthroplasty with soft tissue repair. *Clin Orthop Relat Res*. 2004;418:162–167.
30. Suh KT, Roh HL, Moon KP, Shin JK, Lee JS. Posterior approach with posterior soft tissue repair in revision total hip arthroplasty. *J Arthroplasty*. 2008;23:1197–1203.
31. Turcotte R, Godin C, Duchesne R, Jodoin A. Hip fractures and Parkinson's disease: a clinical review of 94 fractures treated surgically. *Clin Orthop Relat Res*. 1990;256:132–136.
32. Varley J, Parker MJ. Stability of hip hemiarthroplasties. *Int Orthop*. 2004;28:274–277.
33. Woolson ST, Rahimtoola ZO. Risk factors for dislocation during the first 3 months after primary total hip replacement. *J Arthroplasty*. 1999;14:662–668.