Clin Orthop Relat Res (2009) 467:2426–2435
DOI 10.1007/s11999-008-0672-y

ORIGINAL ARTICLE

Cemented versus Uncemented Hemiarthroplasty for Displaced Femoral Neck Fractures

**Wender Figved MD, Vidar Opland MD,
Frede Frihagen MD, Tore Jervidalo MD,
Jan Erik Madsen MD, PhD, Lars Nordsletten MD, PhD**

Received: 21 August 2008 / Accepted: 3 December 2008 / Published online: 7 January 2009

Abstract Hemiarthroplasty is the most commonly used treatment for displaced femoral neck fractures in the elderly. There is limited evidence in the literature of improved functional outcome with cemented implants, although serious cement-related complications have been reported. We performed a randomized, controlled trial in patients 70 years and older comparing a cemented implant (112 hips) with an uncemented, hydroxyapatite-coated implant (108 hips), both with a bipolar head. The mean Harris hip score showed equivalence between the groups, with 70.9 in the cemented group and 72.1 in the uncemented group after 3 months (mean difference, 1.2) and 78.9 and 79.8 after 12 months (mean difference, 0.9). In the uncemented group, the mean duration of surgery was 12.4 minutes shorter and the mean intraoperative blood loss was 89 mL less. The Barthel Index and EQ-5D scores did not show any differences between the groups. The rates of complications and mortality were similar between groups. Both arthroplasties may be used with good results after displaced femoral neck fractures.
Level of Evidence: Level I, therapeutic study. See the Guidelines for Authors for a complete description of levels of evidence.

The institution of the authors has received funding from Eastern Norway Regional Health Authority (nonprofit, governmental). One or more of the authors (WF, FF, JEM, LN) have received funding from Smith & Nephew, Inc, and OrtoMedic AS (OrtoMedic market orthopaedic implants manufactured by DePuy).
Each author certifies that his or her 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.

W. Figved, F. Frihagen, J. E. Madsen, L. Nordsletten
Orthopaedic Centre, Ullevål University Hospital, Oslo, Norway

W. Figved (✉), V. Opland, T. Jervidalo
Orthopaedic Department, Asker and Baerum Hospital,
1309 Rud, Norway
e-mail: wender@me.com

W. Figved, J. E. Madsen, L. Nordsletten
University of Oslo, Faculty Division Ullevål University Hospital, Oslo, Norway

Introduction

Hemiarthroplasty is the most common treatment for displaced fractures of the femoral neck in the elderly [3] and is associated with better functional outcome and fewer reoperations than internal fixation [12, 30]. A large number of prostheses have been used, and no definite conclusions have been made regarding which type of arthroplasty is preferred [29].

There is some evidence of inferior short-term results, with decreased mobility and more pain when using an uncemented implant, and concerns regarding fixation problems with uncemented stems in osteoporotic bone have been raised. This may be the result of the inferior method of fixation or the design of the prosthesis [21, 29]. One randomized comparison of an hydroxyapatite (HA)-coated implant and a conventional uncemented implant showed better functional results with the HA-coated prosthesis [25], and we are unaware of any randomized trials comparing hemiarthroplasties using uncemented HA-coated implants with cemented implants for treatment of femoral neck fractures. An arthroplasty using a cemented implant may be associated with increased mortality compared with an arthroplasty using an uncemented implant [8, 24, 31, 32]. The mechanisms involved are not fully understood but involve cardiorespiratory disturbances caused by venous

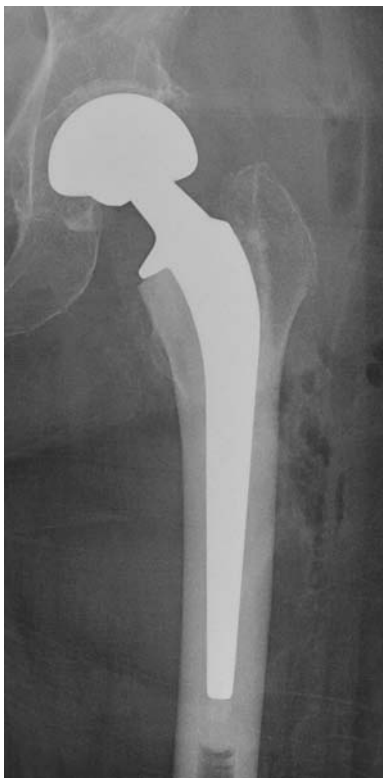

Fig. 1 A radiograph shows the Spectron^{TM} cemented bipolar implant.

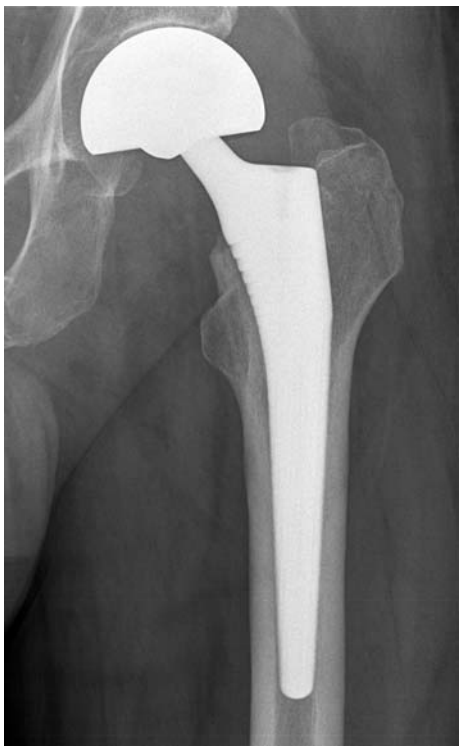

Fig. 2 A radiograph shows the Corail® uncemented bipolar implant.

and pulmonary embolization of bone marrow contents and methylmethacrylate particles [5, 6, 8, 11, 32, 36, 39]. An uncemented implant may be associated with design-specific complications such as stress shielding, thigh pain, and a higher risk of periprosthetic fracture [1, 23].

Whether a specific type of hemiarthroplasty using an uncemented implant could yield the same clinical results as a hemiarthroplasty using a cemented implant for treatment of displaced femoral neck fractures is unclear. The purpose of this two-center randomized equivalence trial was to compare a hemiarthroplasty using a well-documented cemented implant [13, 19] (Fig. 1) with a hemiarthroplasty using a well-documented HA-coated proximal press-fit uncemented implant [16, 35] (Fig. 2), with the following three research aims: (1) Will any differences in intraoperative events be detectable? (2) Are there any differences in functional outcome and quality of life at 3 months and 1 year or are the results equivalent? (3) Are the rates of postoperative morbidity and mortality similar between the two groups?

Materials and Methods

This prospectively randomized trial was performed at two hospitals, one a district general hospital and one a university hospital. Recruitment was from September 2004 to August 2006. We included 150 fractures at the first hospital from September 2004 to July 2006 and 80 fractures at the second hospital from September 2005 to August 2006. Patients 70 years or older who were admitted to one of the two participating hospitals with a displaced intracapsular femoral neck fracture were eligible for inclusion. Patients who were unfit for arthroplasty according to the anesthesiologist on call, had previous symptomatic hip disease such as osteoarthritis, had fracture caused by malignant disease, had ongoing infectious disease, or were unable to walk before the fracture were excluded. Randomization was performed separately for the two hospitals using a computer random number generator with permuted blocks of five. Allocation was done by the surgeon on call using sealed, numbered, opaque envelopes. All patients who were able to provide informed consent did so. Patients who were not able to provide informed consent because of cognitive impairment were included if it was considered to be in their best interest after consultation with their family. The protocol was approved by the regional ethics committee.

Using the equivalence criterion [33], 60 hips in each group were required to have a power of 95% to show the mean Harris hip score (HHS) is the same in both groups, assuming a common standard deviation of 15 and a difference in means of 10 points or less is unimportant using a

two-sided alpha set to 0.05. To allow for some mortality and loss to followup, we decided to include 230 hips.

Of the 390 patients with 402 intracapsular femoral neck fractures admitted to the two hospitals, 239 patients (247 fractures) were eligible for inclusion and we recruited 223 patients (230 fractures) (Fig. 3). Seven patients with both hips were included; five were included with one hip in each group, one with both hips in the cemented group, and one with both hips in the uncemented group. There were three protocol violations in the cemented group and seven in the uncemented group (Fig. 3), leaving 112 and 108 hips in the respective groups for the per-protocol analyses. All patients were invited to followups in an outpatient clinic. Those who were unable or unwilling to attend followups were visited in their home or nursing home or interviewed by telephone. Visits to nursing homes were accompanied by a mobile radiographic unit when possible. Telephone interviews were supplemented with information from health personnel and family members whenever possible. One patient withdrew from the trial after the 3-month followup, and one patient in each group was followed up by telephone only. No patients were completely lost to followup. The EQ-5D interviews were not conducted by telephone or for patients with impaired mental function. At baseline, the groups were similar (Table 1).

Thirty-six surgeons performed a median of five operations each (range, 1–17). Patients underwent a bipolar

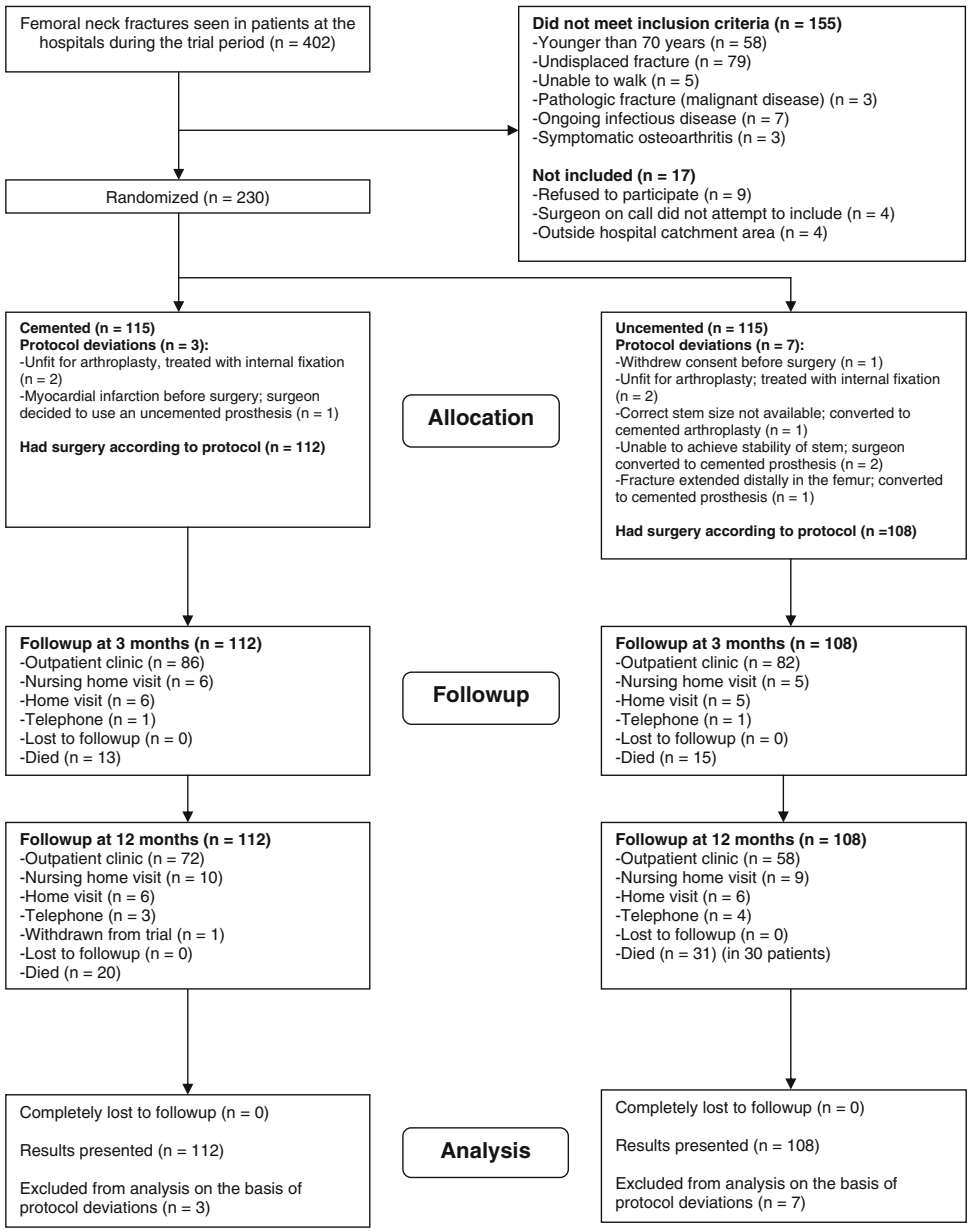

Fig. 3 The flowchart shows recruitment and flow of patients with femoral neck fractures during the study.

Table 1. Baseline and demographic characteristics of patients according to treatment*

Variable	Cemented (n = 112)	Uncemented (n = 108)
Age at fracture (years)	83.4 (5.68)	83.0 (6.29)
Women	87 (78%)	80 (74%)
American Society of Anesthesiologists Group I or II	47 (42%)	47 (44%)
Living in own home	77 (69%)	76 (70%)
Preoperative Harris hip score	82.4 (16.29)	84.6 (15.05)
Able to walk without any aid	56 (50%)	59 (55%)
Previously recognized cognitive failure	26 (23%)	28 (26%)

* Values are expressed as mean, with standard deviation in parentheses, or as number of hips, with percentage in parentheses.

hemiarthroplasty with either a cemented femoral stem (Spectron™; Smith & Nephew, Inc, Memphis, TN) (Fig. 1) or an uncemented femoral stem (Corail®; DePuy International Ltd, Leeds, UK) (Fig. 2). The cemented stem is a straight, collared stem made of a cobalt-chromium alloy. Its proximal third is grit-blasted. The distal part is smoother and a centralizer is attached to its tip. The uncemented stem is grit-blasted titanium alloy with a proximal press-fit design entirely plasma sprayed with HA. All patients received a 28-mm cobalt-chromium head and the same bipolar head (Mobile Cup; DePuy). The arthroplasties were performed through a posterior approach with the patient in a lateral decubitus position using spinal anesthesia. A third-generation cementing technique was used for the cemented stems [28]. All patients were given 2 g preoperative intravenous cefalotin and an additional three doses the first 16 hours after the operation. All patients received 5000 IU low-molecular-weight heparin subcutaneously daily for at least 7 days. The surgeons on call performed all procedures with no changes in the departmental routines connected to the study. Early mobilization was encouraged in all patients with weightbearing as tolerated.

Hip function was rated with the HHS [17, 18, 40], which ranges from 0 to 100 points covering a maximum of 44 points for absence of pain, 47 points for function, and 9 points for range of motion and absence of deformity. The primary outcome was the HHS after 12 months. The Barthel Index (BI) was used to rate ability to perform activities of daily living (ADL) [26]. The BI comprises 10 items about basic ADL: feeding, grooming, bathing, dressing, bowel care, bladder care, toilet use, ambulation, transfers, and stair climbing. The total score range of the BI is from 0 to 20. Health-related quality of life was rated by the patient-assessed EQ-5D (EuroQol) [10]. We used the EQ-5D index scores and the EQ-5D visual analog scale ranging from 0 (worst possible health) to 100 (best possible health) [7]. Walking ability, living arrangements, and use of analgesics were registered. Complications and reoperations were noted.

Data were collected at four times: at admission, at 1 week or at discharge, and at 3 and 12 months. The surgeon on call collected data during admission. Surgical details were recorded by the operating surgeon. Two trained research nurses at each hospital collected data at discharge from the hospital and at 3- and 12-month followups either in the outpatient clinic or via house call or visit to a nursing home. The research nurses were blinded to the intervention.

To minimize the risk of falsely concluding equivalence, all analyses were conducted on a per protocol basis; that is, participants not operated on according to the allocated treatment were not included in the analysis [33]. We used the two-tailed Fisher's exact test for dichotomous variables and t tests for HHS, EQ-5D index score, and analyses of continuous variables.

Results

The duration of surgery and intraoperative blood loss were less in the uncemented group (Table 2). There were no differences in length of surgical incision, need for blood transfusions, postoperative blood loss (closed suction drainage), or length of hospital stay. There was one intraoperative fracture of the greater trochanter requiring cerclage wiring in the uncemented group. In addition, an undisplaced femoral fracture at the distal tip of the prosthesis was revealed on the postoperative radiographs in the same patient and one additional patient in the uncemented group. Both were treated nonoperatively with no additional complications. In the cemented group, one displaced periprosthetic fracture was revealed on the postoperative radiographs and subsequently was treated with open reduction and plate fixation.

None of the three functional outcome scales, HHS, BI, and EQ-5D, showed any differences between the groups (Table 3). For HHS, the results were equivalent (Fig. 4). There were no differences in ability to walk, use of analgesics, or place of living.

Complications were distributed equally between the groups (Tables 4, 5). Seven patients in the cemented group and eight in the uncemented group needed one or more reoperations (range, 1–3). There were no intraoperative deaths, but there were four postoperative deaths within 72 hours; one patient in the cemented group experienced a severe decrease in blood pressure during the cementing procedure and died within 24 hours owing to an acute myocardial infarction. Another patient in the cemented group experienced cardiac arrest during wound closure and died of a myocardial infarction within 72 hours. One

Table 2. Characteristics during and after surgery for patients according to treatment[*,†]

Variable	Cemented	Uncemented	Mean difference or relative risk (95% CI)	p Value
Perioperative details				
Time from admission to surgery (hours)	21.9 (18.3) (n = 112)	19.1 (14.4) (n = 108)	2.8[‡] (−1.6–7.1)	0.22
Duration of surgery (minutes)	82.6 (19.8) (n = 112)	70.2 (19.3) (n = 108)	12.4[‡] (7.2–17.6)	< 0.001
Length of surgical incision (cm)	14.1 (2.72) (n = 100)	13.6 (2.60) (n = 97)	0.47[‡] (−0.28–1.22)	0.22
Main surgeons > 3 years' experience with procedure	72 (64%) (n = 112)	60 (56%) (n = 108)	0.86 (0.70–1.08)	0.22
Intraoperative blood loss (mL)	390 (183.7) (n = 111)	300 (171.9) (n = 108)	89[‡] (42–137)	< 0.001
Postoperative drainage blood loss (mL)	220 (147.3) (n = 105)	233 (157.3) (n = 101)	12.5[‡] (−54.4–29.3)	0.56
Total blood loss (mL)	598 (278) (n = 111)	521 (265) (n = 107)	77[‡] (4.6–149.6)	0.037
Hospital stay				
Received blood transfusion while admitted	47 (42%) (n = 111)	36 (34%) (n = 106)	0.80 (0.57–1.13)	0.21
Hospital stay (days)	7.8 (4.11) (n = 109)	8.4 (9.02) (n = 106)	0.62[‡] (−2.49–1.26)	0.52
Mortality[§]				
Within 7 days	3 (3%) (n = 108)	4 (4%) (n = 105)	1.37 (0.31–5.98)	0.72
Within 30 days	4 (4%) (n = 108)	8 (8%) (n = 105)	2.06 (0.64–6.63)	0.25
Within 90 days	13 (12%) (n = 108)	15 (14%) (n = 105)	1.19 (0.59–2.37)	0.69
Within 12 months	20 (19%) (n = 108)	30 (29%) (n = 105)	1.54 (0.94–2.54)	0.11
Within 24 months	32 (30%) (n = 108)	36 (34%) (n = 105)	1.16 (0.78–1.72)	0.56

[*] Number (n) varies because some information was missing for some patients; [†]values are expressed as mean, with standard deviation in parentheses, or as number of hips, with percentage in parentheses; [‡]mean difference; [§]seven patients were included with both hips and are included only with their first hip in the mortality analyses; only one of these patients died during the study period (both hips in the uncemented group) and would not have influenced the significance of the analyses; 95% CI = 95% confidence interval.

Table 3. Functional outcomes in patients according to allocated treatment[*,†]

Outcome measure	Cemented	Uncemented	Mean difference or relative risk (95% CI)	p Value
Harris hip score				
Baseline	82.4 (16.3) (n = 112)	84.6 (15.1) (n = 108)	2.26[‡] (−1.9–6.4)	0.29
At 3 months	70.9 (18.5) (n = 99)	72.1 (19.7) (n = 90)	1.18[‡] (−4.3–6.7)	0.67
At 12 months	78.9 (15.7) (n = 90)	79.8 (17.6) (n = 77)	0.89[‡] (−4.2–6.0)	0.73
Barthel Index of 19 or 20				
Baseline	59 (53%) (n = 112)	58 (54%) (n = 108)	1.02 (0.77–1.36)	0.89
At discharge (7 days)	8 (7%) (n = 109)	14 (14%) (n = 104)	1.07 (0.98–1.17)	0.18
At 3 months	44 (44%) (n = 100)	45 (50%) (n = 90)	1.12 (0.86–1.47)	0.47
At 12 months	45 (49%) (n = 91)	48 (62%) (n = 77)	1.34 (0.94–1.91)	0.12
EQ-5D index score				
At 3 months	0.64 (0.26) (n = 73)	0.58 (0.30) (n = 70)	−0.06[‡] (−0.15–0.34)	0.21
At 12 months	0.68 (0.23) (n = 56)	0.61 (0.32) (n = 57)	−0.08[‡] (−0.18–0.03)	0.15
EQ-5D visual analog scale				
At 3 months	60 (17.7) (n = 78)	62 (22.4) (n = 68)	2.3[‡] (−4.2 to 8.9)	0.49
At 12 months	61 (17.7) (n = 61)	65 (20.1) (n = 60)	3.6[‡] (−3.2–10.4)	0.30
Living in own home				
Baseline	77 (69%) (n = 112)	76 (70%) (n = 108)	1.02 (0.86–1.22)	0.89
At discharge[§]	4 (4%) (n = 109)	5 (5%) (n = 106)	1.29 (0.36–4.66)	0.75
At 3 months	66 (66%) (n = 100)	61 (68%) (n = 90)	1.03 (0.84–1.26)	0.88
At 12 months	59 (65%) (n = 91)	59 (77%) (n = 77)	1.18 (0.97–1.44)	0.13
Not in need of any pain medication				
Baseline	90 (80%) (n = 112)	90 (83%) (n = 108)	1.04 (0.92–1.18)	0.60
At discharge[§]	6 (6%) (n = 109)	5 (5%) (n = 106)	0.86 (0.27–2.72)	1.00
At 3 months	60 (60%) (n = 100)	54 (60%) (n = 90)	1.00 (0.79–1.26)	1.00
At 12 months	68 (75%) (n = 91)	63 (82%) (n = 77)	1.10 (0.93–1.28)	0.35
Able to walk independently using any aids				
Baseline	112 (100%) (n = 112)	108 (100%) (n = 108)		
At discharge[§]	88 (81%) (n = 109)	80 (75%) (n = 106)	0.94 (0.81–1.08)	0.41
At 3 months	94 (94%) (n = 100)	82 (91%) (n = 90)	0.97 (0.89–1.05)	0.58
At 12 months	87 (96%) (n = 91)	71 (92%) (n = 77)	0.96 (0.89–1.04)	0.52

[*] Number (n) varies because some information was missing for some patients; [†]values are expressed as mean, with standard deviation in parentheses, or as number of hips, with percentage in parentheses; [‡]mean difference; [§]data collected at discharge from hospital or as close to 7 days as possible; 95% CI = 95% confidence interval.

patient in each group died of respiratory failure within 72 hours. The 1-year mortality was similar in the two groups, with 29% in the uncemented group and 19% in the cemented group (relative risk [RR], 1.54; 95% confidence interval [CI], 0.94–2.54; p = 0.11). The 2-year mortality rate also was similar, with 30% in the cemented group and 34% in the uncemented group (RR, 1.16; 95% CI, 0.78–1.72; p = 0.56).

Discussion

Hemiarthroplasty is the most commonly used treatment for displaced femoral neck fractures in the elderly. There is limited evidence in the literature of improved functional outcome with cemented implants, although serious cement-related complications have been reported. The aim of our study was to examine whether the uncemented femoral stem used in this trial would perform similarly to the cemented stem in short- to midterm followup. We specifically studied differences in intraoperative events, functional outcome, and health-related quality of life at 3 months and 1 year of followup, and postoperative morbidity and mortality.

The results in this study should be interpreted with caution as a comparison of any cemented and uncemented hemiarthroplasties. This trial does not have the statistical power to address the potential adverse effects of cement,

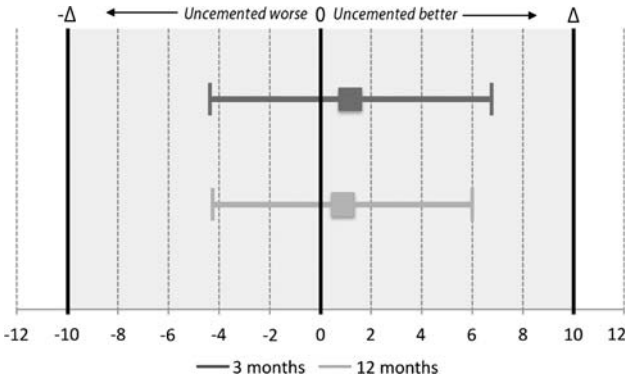

Fig. 4 The graph shows the mean difference in HHS between the two groups at 3 and 12 months. The error bars indicate 95% confidence intervals (CIs). The tinted area indicates the zone of equivalence, defined as ± 10 points (Δ). Both CIs lie wholly inside the zone of equivalence and include zero, indicating the results in the uncemented group were equivalent but not superior to those in the cemented group.

and we did not find any indications of differences between the groups related to cementing, including mortality. The incidence of serious cement-related complications has been reported to be low [32], and a trial examining this would require several thousand patients. This limitation of the study also applies to potential differences in complications related to stem design, including periprosthetic fractures and difficulties with stem fixation during surgery as experienced in three hips in this trial, which also may be related to the experience of the surgeon. One long-term followup trial with this uncemented stem with excellent results has been published [35], and the Norwegian Arthroplasty Register shows a very low revision rate [16]. Large register studies may be needed to assess whether the implants used in this study have different risks of periprosthetic fractures.

The primary functional outcome measure, HHS after 1 year, was equivalent between the two groups. The duration of surgery and intraoperative blood loss were less in the uncemented group. There currently are no published results suggesting one type or brand of cemented bipolar implant used for hemiarthroplasty is superior to another. We believe most well-documented femoral stems used with a bipolar head would yield similar results. Using a stem with good results in patients with osteoarthritis is a safe choice given the abundance of high-quality studies of femoral stems used for THA. Implants that are marketed for fracture treatment only often lack this kind of documentation and traditionally have not been included in large arthroplasty registers.

The Cochrane report on arthroplasties for proximal femoral fractures discusses the problems with the diversity of implants used in various clinical trials [29]. Categorizing all hemiarthroplasties studied in the literature into either a cemented or an uncemented group for analyses of functional outcomes will inadvertently fail to address the implications of the design of the prosthesis and the different methods and principles of fixation other than cement. Excellent clinical results with several uncemented stems in THA have been reported [14, 15, 22, 35, 38]. One series of

Table 4. Complications up to 12 months*

Complication	Cemented (n = 112)	Uncemented (n = 108)
Pneumonia	2 (1.8%)	3 (2.8%)
Dislocation	5 (4.5%)	5 (4.6%)
Deep venous thrombosis	0 (0%)	0 (0%)
Superficial (wound) infection	1 (0.9%)	0 (0%)
Pulmonary embolism	0 (0%)	0 (0%)
Fracture of the contralateral hip†	4 (3.7%) (n = 108)	6 (5.7%) (n = 105)
Deep infection	3 (2.7%)	1 (0.9%)
Intraoperative periprosthetic fracture	1 (0.9%)	2 (1.9%)
Postoperative periprosthetic fracture	1 (0.9%)	4 (3.7%)
Postoperative myocardial infarction not leading to death	1 (0.9%)	1 (0.9%)
Perioperative death (within 72 hours)	3‡,§ (2.7%)	1 (0.9%)
Intraoperative severe decrease in blood pressure during preparation of the femoral canal	2‡ (1.8%)	0 (0%)
Perioperative myocardial infarction leading to death	1‡,§ (0.9%)	0 (0%)
Intraoperative cardiac arrest	1§ (0.9%)	0 (0%)

* All complications are counted so more than one may apply for each hip; values are expressed as number of hips, with percentage in parentheses; †seven patients presenting with a fracture of the contralateral hip were included in the study with the second hip; the remaining three did not have a displaced femoral neck fracture and were treated with internal fixation; ‡one patient had severe loss of blood pressure during the cementing procedure and death within 24 hours of a myocardial infarction; §one patient experienced intraoperative cardiac arrest during wound closure; successful resuscitation but died of an acute myocardial infarction within 72 hours.

Table 5. Details of major complications and reoperations up to 12 months

Gender	Age (years)	Time of event from index operation (days)	Event	Number of reoperations	Time of death from index operation (days)
Cemented (n = 8)					
Male	81	47	Fracture of the trochanter after new trauma; treated nonoperatively	0	203
Female	76	20	Dislocation treated with open reduction, reaming of the acetabulum, and exchange of the modular head and the bipolar head	1	33
Female	87		Intraoperative periprosthetic fracture during preparation of the femoral canal; discovered on postoperative radiographs and treated with plate fixation 5 days after index operation	1	Not dead
Female	88	21	Dislocation treated with open reduction, subsequent redislocation next day, treated with conversion THA with a cemented acetabular cup and a posterior labrum augmentation device	2	Not dead
Female	84	12	Dislocation treated with open reduction; deep infection and redislocation 24 days later treated with open reduction and soft tissue débridement and intravenous antibiotics; redislocation after 12 more days treated with a Girdlestone procedure	3	86
Female	86	41	Dislocation treated with closed reduction, repeated after new dislocation 17 days later; subsequent redislocation treated with conversion THA with an antiluxation acetabular cup	1	Not dead
Female	81	17	Deep infection treated with soft tissue débridement and intravenous antibiotics	1	Not dead
Male	79	7	Dislocation treated with closed reduction; redislocation 5 days later treated with conversion THA with an antiluxation acetabular cup; positive intraoperative bacterial cultures, treated with intravenous antibiotics; redislocation 34 days later treated with a Girdlestone procedure	2	52
Uncemented (n = 11)					
Male	81	6	Dislocation after 6 and 11 days; both times treated with open reduction, second time with reaming of the acetabulum	2	31
Female	90	18	Deep infection treated with soft tissue débridement, intravenous antibiotics, and exchange of modular and bipolar head	1	57
Female	88	1	Dislocation treated with closed reduction	0	8
Female	79		Intraoperative fracture of the trochanter treated with cerclage wiring, and intraoperative fracture at the distal tip of the prosthesis treated nonoperatively	0	Not dead
Male	91	36	Periprosthetic fracture after new trauma; treated with revision hemiarthroplasty and cerclage wiring	1	90
Female	85		Intraoperative fracture at the distal tip of the prosthesis treated nonoperatively	0	Not dead
Female	84	80	Undisplaced fracture of the trochanter treated nonoperatively; dislocation 26 days later treated with conversion THA with a cemented acetabular cup and a posterior labrum augmentation device	1	170
Female	79	80	Periprosthetic fracture after new trauma; treated with plate fixation	1	339

Table 5. continued

Gender	Age (years)	Time of event from index operation (days)	Event	Number of reoperations	Time of death from index operation (days)
Male	85	21	Dislocation treated with closed reduction, subsequent redislocation the next day treated with a Girdlestone procedure owing to the condition of the patient	1	60
Female	94	58	Interprosthetic dislocation treated with open reduction and exchange of a standard to a +12-mm modular head; subsequent periprosthetic fracture treated with revision cemented hemiarthroplasty and cerclage wires	2	Not dead
Male	90	9	Periprosthetic fracture treated with plate fixation	1	278

uncemented hemiarthroplasties using a proximal press-fit design showed excellent results [2], but other results of uncemented hemiarthroplasties, often using stems different from those in THA, are more uncertain. The uncemented Austin Moore prosthesis (Howmedica, Rutherford, NJ) is commonly used [3], and several randomized trials included in review articles include the results of this specific implant. One randomized trial reported better results regarding pain when using an uncemented HA-coated implant in comparison to results with the Austin Moore prosthesis [25]. Another randomized trial showed a low HHS in the Austin Moore group when compared with THA [34]. It also was reported that survival of the Austin Moore prosthesis is inferior to that of cemented implants [9]. Even so, it still is being defended as a treatment option for frail elderly patients [27]. In contrast, one recent randomized trial comparing an arthroplasty using a cemented Exeter™ bipolar implant (Stryker UK Ltd, Newbury, UK) with THA showed excellent functional outcomes in both groups [4]. Although the HHS was higher in the THA group, there was no difference in the ADL or EQ–5D scores [4]. Although these trials are not comparable, they strongly indicate different results in different types of hemiarthroplasties.

The costs of the implants used in our trial are comparable, but both are more expensive than implants marketed for fracture treatment only. This increased implant cost at the index surgery must be weighed against the cost of possibly poorer functional results and more revision procedures.

Additional research should focus on specific types of implants for treatment of femoral neck fractures. Recently initiated hemiarthroplasty registers in Norway and Sweden will acquire large numbers of patients and contribute information regarding the choice of implant. With increased life expectancies in most Western countries, the importance of the longevity of implants for treatment of femoral neck fractures should be appreciated; prostheses with high revision rates should be avoided. Possible differences in acetabular wear between types of implants should be assessed. The role of THA for treatment of femoral neck fractures also should be addressed further, because there is evidence of better results with THA in the subpopulation of fit patients with little comorbidity [4, 20, 37].

For treatment of displaced femoral neck fractures, we recommend performing hemiarthroplasties using femoral stems that have performed well in THAs. Cemented and uncemented prostheses used in this trial can be recommended because they were equally good regarding functional outcome and health-related quality of life, contrary to the generalized and limited published evidence. We did not observe a difference in rare complications such as periprosthetic fractures and cement-related complications. The seeming advantages of shorter duration of surgery and potentially less blood loss with the uncemented implant are of little importance compared with the important findings of equivalent functional results. Both implants may be used with good results after displaced femoral neck fractures.

Acknowledgments We thank Merete Finjarn, Kenneth Nilsen, Karen Bjøro, and Camilla Andersen for impeccable data collection and patient logistics; Sigmund Oswold for ambulant radiographic examinations; and Asbjørn Hjall and Wenche Sørensen for initiation support and making this trial feasible in a busy orthopaedic department.

References

1. Berry DJ. Epidemiology: hip and knee. *Orthop Clin North Am.* 1999;30:183–190.
2. Bezwada HP, Shah AR, Harding SH, Baker J, Johanson NA, Mont MA. Cementless bipolar hemiarthroplasty for displaced femoral neck fractures in the elderly. *J Arthroplasty.* 2004;19(7 suppl 2):73–77.
3. Bhandari M, Devereaux PJ, Tornetta P 3rd, Swiontkowski MF, Berry DJ, Haidukewych G, Schemitsch EH, Hanson BP, Koval K, Dirschl D, Leece P, Keel M, Petrisor B, Heetveld M, Guyatt GH. Operative management of displaced femoral neck fractures in elderly patients: an international survey. *J Bone Joint Surg Am.* 2005;87:2122–2130.

4. Blomfeldt R, Tornkvist H, Eriksson K, Soderqvist A, Ponzer S, Tidermark J. A randomised controlled trial comparing bipolar hemiarthroplasty with total hip replacement for displaced intracapsular fractures of the femoral neck in elderly patients. *J Bone Joint Surg Br.* 2007;89:160–165.
5. Christie J, Burnett R, Potts HR, Pell AC. Echocardiography of transatrial embolism during cemented and uncemented hemiarthroplasty of the hip. *J Bone Joint Surg Br.* 1994;76:409–412.
6. Clark DI, Ahmed AB, Baxendale BR, Moran CG. Cardiac output during hemiarthroplasty of the hip: a prospective, controlled trial of cemented and uncemented prostheses. *J Bone Joint Surg Br.* 2001;83:414–418.
7. Dolan P, Gudex C, Kind P, Williams A. The time trade-off method: results from a general population study. *Health Econ.* 1996;5:141–154.
8. Duncan JA. Intra-operative collapse or death related to the use of acrylic cement in hip surgery. *Anaesthesia.* 1989;44:149–153.
9. Eiskjaer S, Ostgard SE. Survivorship analysis of hemiarthroplasties. *Clin Orthop Relat Res.* 1993;286:206–211.
10. EuroQol Group. EuroQol: a new facility for the measurement of health-related quality of life. *Health Policy.* 1990;16:199–208.
11. Fallon KM, Fuller JG, Morley-Forster P. Fat embolization and fatal cardiac arrest during hip arthroplasty with methylmethacrylate. *Can J Anaesth.* 2001;48:626–629.
12. Frihagen F, Nordsletten L, Madsen JE. Hemiarthroplasty or internal fixation for intracapsular displaced femoral neck fractures: randomised controlled trial. *BMJ.* 2007;335:1251–1254.
13. Garellick G, Malchau H, Herberts P. The Charnley versus the Spectron hip prosthesis: clinical evaluation of a randomized, prospective study of 2 different hip implants. *J Arthroplasty.* 1999;14:407–413.
14. Grant P, Grogaard B, Nordsletten L. Ultralok uncemented femoral prostheses: 12 to 15 year follow-up evaluation. *J Arthroplasty.* 2004;19:274–280.
15. Grant P, Nordsletten L. Total hip arthroplasty with the Lord prosthesis: a long-term follow-up study. *J Bone Joint Surg Am.* 2004;86:2636–2641.
16. Hallan G, Lie SA, Furnes O, Engesaeter LB, Vollset SE, Havelin LI. Medium- and long-term performance of 11,516 uncemented primary femoral stems from the Norwegian arthroplasty register. *J Bone Joint Surg Br.* 2007;89:1574–1580.
17. Harris WH. Traumatic arthritis of the hip after dislocation and acetabular fractures: treatment by mold arthroplasty: an end-result study using a new method of result evaluation. *J Bone Joint Surg Am.* 1969;51:737–755.
18. Hoeksma HL, Van Den Ende CH, Ronday HK, Heering A, Breedveld FC. Comparison of the responsiveness of the Harris Hip Score with generic measures for hip function in osteoarthritis of the hip. *Ann Rheum Dis.* 2003;62:935–938.
19. Issack PS, Botero HG, Hiebert RN, Bong MR, Stuchin SA, Zuckerman JD, Di Cesare PE. Sixteen-year follow-up of the cemented Spectron femoral stem for hip arthroplasty. J Arthroplasty. 2003;18:925–930.
20. Keating JF, Grant A, Masson M, Scott NW, Forbes JF. Randomized comparison of reduction and fixation, bipolar hemiarthroplasty, and total hip arthroplasty: treatment of displaced intracapsular hip fractures in healthy older patients. *J Bone Joint Surg Am.* 2006;88:249–260.
21. Khan RJ, MacDowell A, Crossman P, Datta A, Jallali N, Arch BN, Keene GS. Cemented or uncemented hemiarthroplasty for displaced intracapsular femoral neck fractures. *Int Orthop.* 2002;26:229–232.
22. Laupacis A, Bourne R, Rorabeck C, Feeny D, Tugwell P, Wong C. Comparison of total hip arthroplasty performed with and without cement: a randomized trial. *J Bone Joint Surg Am.* 2002;84:1823–1828.
23. Learmonth ID, Young C, Rorabeck C. The operation of the century: total hip replacement. *Lancet.* 2007;370:1508–1519.
24. Lennox IA, McLauchlan J. Comparing the mortality and morbidity of cemented and uncemented hemiarthroplasties. *Injury.* 1993;24:185–186.
25. Livesley PJ, Srivastiva VM, Needoff M, Prince HG, Moulton AM. Use of a hydroxyapatite-coated hemiarthroplasty in the management of subcapital fractures of the femur. *Injury.* 1993;24:236–240.
26. Mahoney FI, Barthel DW. Functional evaluation: the Barthel Index. *Md State Med J.* 1965;14:61–65.
27. Norrish AR, Rao J, Parker MJ. Prosthesis survivorship and clinical outcome of the Austin Moore hemiarthroplasty: an 8-year mean follow-up of a consecutive series of 500 patients. *Injury.* 2006;37:734–739.
28. Oishi CS, Walker RH, Colwell CW Jr. The femoral component in total hip arthroplasty: six to eight-year follow-up of one hundred consecutive patients after use of a third-generation cementing technique. *J Bone Joint Surg Am.* 1994;76:1130–1136.
29. Parker MJ, Gurusamy K. Arthroplasties (with and without bone cement) for proximal femoral fractures in adults. *Cochrane Database Syst Rev.* 2006;3:CD001706.
30. Parker MJ, Gurusamy K. Internal fixation versus arthroplasty for intracapsular proximal femoral fractures in adults. *Cochrane Database Syst Rev.* 2006;4:CD001708.
31. Parvizi J, Ereth MH, Lewallen DG. Thirty-day mortality following hip arthroplasty for acute fracture. *J Bone Joint Surg Am.* 2004;86:1983–1988.
32. Parvizi J, Holiday AD, Ereth MH, Lewallen DG. The Frank Stinchfield Award. Sudden death during primary hip arthroplasty. *Clin Orthop Relat Res.* 1999;369:39–48.
33. Piaggio G, Elbourne DR, Altman DG, Pocock SJ, Evans SJ. Reporting of noninferiority and equivalence randomized trials: an extension of the CONSORT statement. *JAMA.* 2006;295:1152–1160.
34. Ravikumar KJ, Marsh G. Internal fixation versus hemiarthroplasty versus total hip arthroplasty for displaced subcapital fractures of femur: 13 year results of a prospective randomised study. *Injury.* 2000;31:793–797.
35. Reikeras O, Gunderson RB. Excellent results of HA coating on a grit-blasted stem: 245 patients followed for 8–12 years. *Acta Orthop Scand.* 2003;74:140–145.
36. Ries MD, Lynch F, Rauscher LA, Richman J, Mick C, Gomez M. Pulmonary function during and after total hip replacement: findings in patients who have insertion of a femoral component with and without cement. *J Bone Joint Surg Am.* 1993;75:581–587.
37. Rogmark C, Johnell O. Primary arthroplasty is better than internal fixation of displaced femoral neck fractures: a meta-analysis of 14 randomized studies with 2,289 patients. *Acta Orthop.* 2006;77:359–367.
38. Rorabeck CH, Bourne RB, Mulliken BD, Nayak N, Laupacis A, Tugwell P, Feeney D. The Nicolas Andry Award. Comparative results of cemented and cementless total hip arthroplasty. *Clin Orthop Relat Res.* 1996;325:330–344.
39. Skyrme AD, Jeer PJ, Berry J, Lewis SG, Compson JP. Intravenous polymethyl methacrylate after cemented hemiarthroplasty of the hip. *J Arthroplasty.* 2001;16:521–523.
40. Soderman P, Malchau H. Is the Harris hip score system useful to study the outcome of total hip replacement? *Clin Orthop Relat Res.* 2001;384:189–197.