Treatment and Displacement Affect the Reoperation Rate for Femoral Neck Fracture

Donavan K. Murphy MD, MSc, MBA,
Timothy Randell MD, Kindyle L. Brennan PhD, PT,
Robert A. Probe MD, Michael L. Brennan MD

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Abstract

Background Femoral neck fractures (FNFs) comprise 50% of geriatric hip fractures. Appropriate management requires surgeons to balance potential risks and associated healthcare costs with surgical treatment. Treatment complications can lead to reoperation resulting in increased patient risks and costs. Understanding etiologies of treatment failure and the population at risk may decrease reoperation rates.

Questions/purposes We therefore (1) determined if treatment modality and/or displacement affected reoperation rates after FNF; and (2) identified factors associated with increased reoperation and timing and reasons for reoperation.

Methods We reviewed 1411 records of patients older than 60 years treated for FNF with internal fixation or hemiarthroplasty between 1998 and 2009. We extracted patient

age, sex, fracture classification, treatment modality and date, occurrence of and reasons for reoperation, comorbid conditions at the time of each surgery, and dates of death or last contact. Minimum followup was 12 months (median, 45 months; range, 12–157 months).

Results Internal fixation (hazard ratio [HR], 6.38) and displacement (HR, 2.92) were independently associated with increased reoperation rates. The reoperation rate for nondisplaced fractures treated with fixation was 15% and for displaced fractures 38% after fixation and 7% after hemiarthroplasty. Most fractures treated with fixation underwent reoperation within 1 year primarily for non-union. Most fractures treated with hemiarthroplasty underwent reoperation within 3 months, primarily for infection.

Conclusions Overall, hemiarthroplasty resulted in fewer reoperations versus internal fixation and displaced fractures underwent reoperation more than nondisplaced. Our data suggest there are fewer reoperations when treating elderly patients with displaced FNFs with hemiarthroplasty than with internal fixation.

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

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Each author certifies that his or her institution 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.

D. K. Murphy (✉), T. Randell, K. L. Brennan,
R. A. Probe, M. L. Brennan
Department of Orthopaedics, Scott & White HealthCare/Texas
A&M Health Science Center, 2401 South 31st Street, Temple,
TX 76508, USA
e-mail: dmurphy@sw.org

Introduction

Femoral neck fractures (FNFs) are common, accounting for approximately 50% of all hip fractures [30]. The number of people in the United States older than 65 years in 2010 was 40 million and will nearly double to 80 million by 2040 [21]. With this elderly population increase, the rate of hip fractures is expected to increase from less than 2 million in 1990 to more than 6 million by 2050 [28]. The increasing

yearly prevalence and morbidity and mortality associated with FNFs have led to extensive research and multiple publications on which to base treatment decisions [1, 4, 5, 9, 19, 25, 26, 31, 33, 36, 38, 42, 45, 47–49, 51].

Patient factors relevant to the treatment of this injury include age, activity, comorbidities, functional demands, and the perceived risk of secondary surgery [3, 9, 21–23, 33, 44, 45, 51]. These must be considered alongside surgeon preference and fracture variables that include displacement, fracture pattern, comminution, and bone quality [7, 11, 21, 25, 45, 51]. Treatment options include nonsurgical management [13, 35, 36], internal fixation with multiple cannulated screws [11, 22, 24, 31, 40, 47, 51, 52], hemiarthroplasty [3, 8, 18, 24, 54], or THA [3, 5, 10, 12, 42, 50].

As a result of the widely published differences in the reoperation rates after initial surgical treatment of nondisplaced [7, 11–13, 21, 45, 47] versus displaced FNFs [3, 8, 18, 22, 31, 38, 42, 44, 52], research has been directed at looking separately at nondisplaced or displaced fractures. Evidence of better hip function scores, quality of life, and lower reoperation rates of THA compared with internal fixation strongly supports the use of THA in healthy, cognitively intact patients [3, 8, 10, 28, 42, 43, 50, 51]. The use of internal fixation in FNFs has been associated with reoperation rates ranging from 10% to 49% [18, 21, 22, 24, 42, 44] compared with 0% to 24% for hemiarthroplasty [5, 18, 36, 44], resulting in a more costly treatment strategy than hemiarthroplasty [1, 25]. Despite increased complications and technical difficulties associated with salvage of failed fixation [16, 23, 34], some argue the higher reoperation rate is offset by the benefits of preservation of the native femoral head and avoidance of potential complications associated with arthroplasty [2, 13, 31]. Mortality at 1 year ranges from 14% to 36% but without differences in mortality between fixation and hemiarthroplasty at 1, 5, and 10 years [8, 18, 19, 31, 36, 37]. Fixation is associated with higher risk of contralateral hip fracture than arthroplasty [48]. Despite the growing amount of research on this subject, no clinical consensus exists regarding how to best treat FNFs with the primary intention of avoiding reoperation in an effort to avoid additional risks to these patients.

Therefore, our purpose was to (1) determine if treatment modality and/or displacement affected reoperation rates after FNF; and (2) identify factors associated with increased reoperation and the timing and reasons for reoperation.

Materials and Methods

We retrospectively reviewed our institutional electronic medical record from 1998 to 2009 using International

Classification of Diseases, 9th Revision and Current Procedural Terminology codes associated with FNFs (27235, 27236, 27132, and 27130) and identified 1788 patients. For this study we included patients meeting the following criteria: age older than 60 years and treatment for FNF. We excluded 377 patients sustaining trauma beyond a simple fall, those with concurrent malignancies, extracapsular hip fracture (OTA/AO 31-B2.1 [31]), prior surgery to the ipsilateral proximal femoral region, and those receiving open reduction or treatment other than internal fixation or hemiarthroplasty. Among the 1788 charts reviewed, 1411 patients (1494 hips) with FNF treated with fixation or hemiarthroplasty met inclusion criteria. Thirteen cases of nondisplaced fractures treated with hemiarthroplasty were excluded, because the standard of care at this institution during this time was to perform internal fixation on nondisplaced fractures unless extenuating circumstances led the surgeon to choose differently. We assumed that the factor(s) that led to the decision in these patients would qualify these cases as outliers. There were 117 patients excluded owing to lack of 1 year of followup. Reoperation-free survival analysis was performed on 1294 patients (1364 hips) who died without reoperation, were followed at least 1 year without reoperation, or underwent reoperation. There were 620 patients treated for a left hip fracture, 604 patients treated for a right hip fracture, and 70 patients treated for bilateral hip fractures. One thousand thirteen fractures (74%) were in females and 351 (26%) were in males. The average age at index surgery was 81 years (SD, 8; range, 60–106 years). Minimum followup of the 1364 fractures was 0 month (median, 23 months; range, 0–157 months), which included 847 (65%) cases in which the patient died, one of whom died the date of surgery yielding the minimum range of 0. Among 1364 total cases, there were 227 reoperations during followup. The remaining patients with 1137 fractures were censored at the last contact date or date of death with a minimum followup of 12 months (median, 45 months; range, 12–157 months) for patients who survived without reoperation (Table 1).

The indications for fixation were (1) nondisplaced fractures; (2) stable fractures; or (3) minimally displaced fractures amenable to closed reduction with intact posteromedial cortex. The indications for hemiarthroplasty were (1) minimally displaced fractures with disrupted posteromedial cortex; or (2) displaced fractures. The contraindications for surgery were (1) nonambulatory patients with severe dementia; or (2) patients deemed too unhealthy for surgery. Six hundred ninety-seven (51%) of the fractures were treated with fixation and 667 (49%) were treated with hemiarthroplasty. Three hundred fifty-eight (26%) of the fractures were nondisplaced and all were treated with fixation. A total of 1006 fractures (74%) were displaced, of which 667 were treated with hemiarthroplasty and 339

Table 1. Revision-free survival estimate (number of patients remaining)

Garden stage	Surgery type	Median revision-free survival	Estimated percent revision-free survival			
			1 month	3 months	12 months	36 months
Nondisplaced	IF (N = 358)	NR*	98.0% (N = 336)	95.3% (N = 311)	86.8% (N = 251)	82.1% (N = 136)
Displaced	HA (N = 667)	NR*	96.5% (N = 591)	94.7% (N = 545)	94.2% (N = 474)	93.1% (N = 270)
	IF (N = 339)	NR*	95.5% (N = 303)	86.3% (N = 259)	65.7% (N = 177)	56.4% (N = 102)

* NR = median revision-free survival was not reached; IF = internal fixation; HA = hemiarthroplasty.

were treated with fixation. For both surgical treatments, surgery was performed or overseen by one of 20 senior staff physicians. Patients treated with multiple screws underwent reduction through closed means on a fracture table and implant placement as described by Probe and Ward [41]. Three ASNIS III (Stryker, Kalamazoo, MI, USA) 6.5-mm cannulated screws were used for fixation on all patients with a fourth screw added if posterior comminution was present [30]. All hemiarthroplasties were performed using a Hardinge lateral approach combined with a modular stem using third-generation cementing techniques.

Postoperatively, patients were allowed to weightbear with unrestricted hip motion as tolerated and were evaluated and managed by a physical therapist. Patients were discharged to nursing homes, skilled nursing facilities, or rehabilitation centers with continuation of physical therapy or were discharged to home with home physical therapy if deemed capable. All patients had their incision evaluated at 2 weeks. Reductions were assessed intraoperatively by fluoroscopy and with routine radiographs at 6 weeks for all patients and were taken accordingly when pain, reinjury, or patient complaint caused concern.

Data obtained from chart review included patient age, sex, surgery performed, date of surgery, fracture classification, complications leading to reoperation, and dates of last contact or death. Patients' death records were obtained from our state's vital statistics based on name, date of birth, and sex. Reoperation was defined as any operation performed owing to complications of the primary procedure. Reason for reoperation was identified retrospectively from review of orthopaedic and radiologic records and classified based on a Cochrane review classification [37] as (1) minor (removal of fixation, closed reduction of dislocated prosthesis); (2) moderate (arthroplasty after fixation, surgical drainage, open reduction of dislocated prosthesis, resection arthroplasty or similar removal of implant and femoral head); or (3) major (conversion of hemiarthroplasty to THA or other revision arthroplasty, periprosthetic fracture). There were six reasons for reoperation in the fixation group according to the primary etiology, which included non-union, avascular necrosis, prominent hardware from collapse causing pain or screw protrusion through the

femoral head, deep infection, periprosthetic fracture, and early loss of reduction. There were seven reasons for reoperation in the hemiarthroplasty group, including deep infection, periprosthetic fracture, heterotopic ossification, dislocation, femoral component loosening, hematoma, and superficial infection.

Fracture displacement was categorized as either nondisplaced or displaced by one of two methods. For patients sustaining their fracture after August 2002, digital radiographs were available for review by one of the authors (TR). Fractures were categorized as nondisplaced if they were AO/OTA 31B3.1-3 (Garden Stages 1 and 2 [20]) and categorized as displaced if they were 31B3.1-3 or 31B2.3 (Garden Stages 3 and 4). The intergrader agreement for Garden Stages 1, 2, 3, and 4 fractures is reportedly low (kappa, 0.03–0.56) but high (kappa, 0.67–0.77) for nondisplaced (Garden Stages 1 and 2) and displaced (Garden Stages 3 and 4) fractures [17, 36, 55]. A subset of radiographs was used to assess and ensure interobserver reliability with two board-certified trauma surgeons and four chief residents. Consistent with previous reports, intergrader reliability was greater than 90% for nondisplaced and displaced fracture groups [17, 35, 55]. For patients sustaining a fracture before August 2002, radiographic images were not available and displacement classification was discerned through review of orthopaedic and radiographic records. We considered this acceptable, because dichotomous classification (displaced/nondisplaced) reportedly has high intergrader reliability [17, 36, 55]. Early loss of reduction was defined as displacement from the surgical reduction within 3 months, determined by the treating surgeon to be unacceptable.

Case characteristics were summarized according to reoperation status (reoperation versus no reoperation) using descriptive statistics, mean (SD), or median (minimum–maximum) for continuous variables and frequency (percent) for categorical variables. Reasons of reoperation were summarized according to displacement and surgery type as frequency (percent). Multivariate Cox proportional hazards regression analysis ($p < 0.05$) was performed using age, sex, surgery type, and displacement status. A univariate Cox proportional hazards regression model ($p < 0.05$) using surgery type was applied to the displaced FNFs. Age,

sex, time to reoperation, and reasons for reoperation were evaluated secondarily for their influence on reoperation rates. Implant survival was calculated for each case using Kaplan-Meier analysis. Patients who did not undergo reoperation were censored at last contact date or date of death. SAS 9.2 (SAS Institute Inc, Cary, NC, USA) was used for data analysis.

Results

Treatment and displacement affected the rate of reoperation in patients with FNFs. Treatment with internal fixation (hazard ratio [HR], 6.38; 95% confidence interval [CI], 4.51–9.05) and the presence of a displaced fracture (HR, 2.92; 95% CI, 2.12–4.02) were independently associated with increased risk of reoperation (Table 2). A total of 233 patients (227 fractures) required reoperation for an overall rate of 16.6%. For hemiarthroplasty and internal fixation overall, the reoperation rates were 6.6% and 26.3%, respectively. When comparing reoperation rates between surgery types in the displaced fractures only, fractures treated with internal fixation were greater than six times

more likely to undergo reoperation (HR, 6.56; 95% CI, 4.65–9.24), with a reoperation rate of 6.6% for hemiarthroplasty and 38% for internal fixation (Table 3). The reoperation rate for nondisplaced fractures (all internal fixation) was 15.1%. Reoperation-free survival estimate at 1 year for the nondisplaced fixation group was 86.8% (95% CI, 82.5%–90.1%). The displaced group estimates were 94.1% for hemiarthroplasty and 65.7% for fixation (Fig. 1) (Table 1).

Age and sex were not significant variables in the rate of reoperation (Table 2). For timing, most reoperations after fixation occur within 1 year and most reoperations after hemiarthroplasty occur within 3 months. In the patients treated with fixation, 42 (78%) with nondisplaced fractures who had reoperations and 101 (78%) with displaced fractures who had reoperations underwent reoperation within 1 year from surgery (Table 4). Thirty-three (75%) of the reoperations in patients treated with hemiarthroplasty occurred within 3 months. Nonunion was the most common reason for reoperation in the patients with nondisplaced fractures and displaced fractures treated with internal fixation. Infection was the leading reason for reoperation in patients with displaced fractures treated with hemiarthroplasty. Avascular necrosis, prominent screws, dislocation, and other reasons for reoperation were seen less commonly (Table 5).

Table 2. Multivariable Cox proportional hazards regression for revision-free survival

Variable	HR (95% CI)	p value
Age (years)	0.99 (0.97–1.01)	0.17
Sex		
Male	1.00	
Female	0.99 (0.74–1.32)	0.93
Surgery type		
Hemiarthroplasty	1.00	
Internal fixation	6.38 (4.51–9.05)	< 0.001
Displacement		
Nondisplaced	1.00	
Displaced	2.92 (2.12–4.02)	< 0.001

HR = hazard ratio; CI = confidence interval.

Discussion

The increasing yearly prevalence and morbidity and mortality associated with FNFs demands the medical community's attention with the purpose of optimal management. Successful management requires the surgeon to balance potential risks and healthcare costs associated with surgery for FNF. One of these risks is reoperation. Higher reoperation rates have been associated with the use of fixation in FNFs [5, 18, 21, 22, 37, 39, 43, 45] resulting in a more costly treatment than hemiarthroplasty [1, 25]. Other associated risks of fixation include increased contralateral

Table 3. Surgery type according to reoperation by displacement

Variable	No reoperation	Reoperation	HR (95% CI)	p value*
Nondisplaced only				
Internal fixation	304 (84.9%)	54 (15.1%)		
Displaced only				
Hemiarthroplasty	623 (92.4%)	44 (6.6%)	1.00	
Internal fixation	210 (62%)	129 (38.1%)	6.56 (4.65–9.24)	< 0.001

* Univariate Cox proportional hazards regression model was used; HR = hazard ratio; CI = confidence interval.

Fig. 1 The Kaplan-Meier reoperation-free survival estimates are shown according to treatment and displacement. Hemiarthroplasty resulted in fewer reoperations versus internal fixation and displaced fractures underwent reoperation more than nondisplaced. The lines indicate the amount of time from surgery to revision for

hemiarthroplasty (HA) displaced, internal fixation (IF) displaced, and IF nondisplaced fractures, respectively. Ninety-five percent confidence intervals at last followup: HA displaced (0.88–0.94), IF displaced (0.43–0.58), and IF nondisplaced (0.76–0.85).

Table 4. Number of reoperations during each interval and number of cumulative reoperations

Each interval	Nondisplaced		Displaced	
Reoperation	IF (N = 358)		IF (N = 339)	HA (N = 667)
0–1 month	7		15	22
1–3 months	9		28	11
3 months to 1 year	26		58	3
1–3 years	11		22	4
More than 3 years	1		6	4
Cumulative	Nondisplaced		Displaced	
Reoperation	IF (N = 358)		IF (N = 339)	HA (N = 667)
Within 1 month	7		15	22
Within 3 months	16		43	33
Within 1 year	42		101	36
Within 3 years	53		123	40

IF = internal fixation; HA = hemiarthroplasty.

hip fractures [49] and complications and technical difficulties associated with salvage of failed fixation [16, 23, 34]. Despite the higher reoperation rates for internal fixation, advocates of this procedure argue this risk is offset by the benefits of preservation of the native femoral head and avoidance of potential complications of arthroplasty [2, 13, 31]. No clinical consensus exists regarding how to best treat FNFs with the primary intention of avoiding reoperation to avoid additional risks to patients. Therefore, our purpose was to (1) determine if treatment modality and/or displacement affected reoperation rates after FNF; and (2)

identify factors associated with increased reoperation and the timing and reasons for reoperation.

We caution readers of the limitations of our study. First, postoperative radiographs were reviewed only for hip fractures on which reoperation was performed. This possibly could lead to underestimation of the occurrence rates of each mechanism of failure. For example, dislocation that undergoes closed reduction in the emergency room and does not proceed to surgery would not be included as a failure in this study. Despite this, our primary outcome measure was reoperation and therefore by design did not

Table 5. Reasons for reoperation

Reoperation reason	Nondisplaced fracture Internal fixation (N = 358)	Displaced fracture Internal fixation (N = 339)	Hemiarthroplasty (N = 667)
Nonunion	20 (5.6%)	62 (18.3%)	0 (0.0%)
Avascular necrosis	9 (2.5%)	19 (5.6%)	0 (0.0%)
Prominent screws/screw protrusion	12 (3.4%)	18 (5.3%)	0 (0.0%)
Periprosthetic fracture	6 (1.7%)	7 (2.1%)	4 (0.6%)
Removal of heterotopic bone	0 (0.0%)	0 (0.0%)	1 (0.1%)
Dislocation	0 (0.0%)	0 (0.0%)	6 (0.9%)
Femoral component loosening	0 (0.0%)	0 (0.0%)	5 (0.7%)
Early loss of reduction	7 (2.0%)	18 (5.3%)	0 (0.0%)
Hematoma	0 (0.0%)	0 (0.0%)	2 (0.3%)
Superficial infection	0 (0.0%)	0 (0.0%)	3 (0.4%)
Deep infection	0 (0.0%)	5 (1.5%)	23 (3.4%)
No reoperation	304 (84.9%)	210 (61.9%)	623 (93.4%)
Reoperation classification			
Total (% of reoperations; % of total)			
Minor	11 (20.4; 3.1)	19 (14.7; 5.6)	3 (6.8; 0.5)
Moderate	37 (68.5; 10.3)	103 (79.8; 30.3)	28 (63.6; 4.2)
Major	6 (11.1; 1.7)	7 (5.4; 2.1)	13 (29.5; 1.9)

include failures not leading to reoperation. Second, during this study period, the treatment modality for displaced FNFs was determined by each staff physician but in keeping with the literature and standard of care at this institution. A shift of treatment modality occurred in 2001, and by 2006, internal fixation of displaced fractures rarely was performed at our institution unless patient factors prevented them from being able to undergo arthroplasty. Leading up to this shift, multiple publications were released noting the efficacy of internal fixation of displaced femoral neck fractures [14, 16, 25, 27, 41–43, 50, 52]. Overall, the inability to control for the exact treatment modality applied in each case is cause for caution in generalizing our results. Third, small variations in surgical technique by the surgeons involved were likely with the many patients treated. Because there was no way to control for these variations retrospectively, they may have had a negative or positive effect, which is not readily evident. However, because surgeon variability was inevitable, but approach and implant remained constant, our findings related to treatment can be attributed more confidently to the surgery rather than the surgeon. Fourth, complications were classified according to minor, moderate, and major based on type of reoperation. This classification scheme did not account for nonsurgical complications and subsequent reoperations because they were not recorded in our chart review. This possibly could contribute to underestimation of the overall morbidity of the procedure and therefore the severity classification. Whether a patient underwent

reoperation was our primary end point and would not be affected by this. Fifth, length of followup is a possible limitation of our results. Late complications of hemiarthroplasty such as acetabular erosion and femoral component loosening can take years to develop [3, 46] and may not have been captured in our study. Although longer followup could have increased the detection of these complications, Parker et al. [38] reported very few reoperations after 3 years with minimum followup of 9 years. Finally, we did not analyze cognitive status or function. Cognitive status may affect how well a patient tolerates recovery, which could affect the reoperation rate [9, 22]. A patient's functional status influences the risk of certain complications such as periprosthetic fracture and acetabular wear leading to reoperation. A measure of functional status also would help to determine the impact of treatment on quality of life [5, 18, 31, 44, 51]. Cognition and functional status could not be adequately assessed retrospectively. However, the large sample size in this study helped to offset the absence of these variables. The data in this study are the result of many patients being treated by 20 senior staff surgeons. Although approach and implant remained constant, it is likely small variations in technique did exist offering real-world applicability to our outcomes.

Bearing in mind these limitations, our data support the use of hemiarthroplasty in the treatment of displaced FNFs. Treatment with internal fixation and fracture displacement was independently associated with increased rates of reoperation, and displaced fractures treated with internal

Table 6. Comparison of studies of reoperation rates for displaced fractures

Study	Study type	Followup (months)	Intervention		Hemiarthroplasty		Internal fixation	
			Hemiarthroplasty	Internal fixation	Reoperations/total	Total reoperation rate (%)	Reoperation/total	Total reoperation rate (%)
Frihagen et al. [18]	RCT	24	Bipolar cemented lateral approach	2 cancellous screws	11 of 108	10.2	47 of 111	42.4
Parker and Gurusamy [37]	RCT	24	Uncemented Austin Moore	3 AO screws	15 of 229	6.6	86 of 226	38.1
Davison et al. [14]	RCT	60	Thompson HA or cemented bipolar	AMBI compression screw and two-hole plate	6 of 187	3.2	28 of 93	30.1
Bjorgul and Reikeras [6]	Prospective	72	Exeter cemented HA	Olmed screws	9 of 455	2	54 of 228	23.7
Blomfeldt et al. [8]	RCT	24	Uncemented Austin Moore	2 cancellous screws	1 of 30	3.3	10 of 30	33.3
Roden et al. [44]	RCT	60	Varikopf bipolar HA	2 von Bahr screws	8 of 47	17	34 of 53	64.2
Soreide et al. [47]	RCT	12	Christiansen bipolar HA	von Bahr screws	5 of 53	9.4	9 of 51	17.6
Svenningsen et al. [50]	RCT	36	Christiansen bipolar HA (cementation unknown)	Compression screw versus McLaughlin nail plate	8 of 59	13.6	16 of 110	14.5
van Vugt et al. [54]	RCT	36	Cemented bipolar HA	Dynamic hip screw	7 of 22	31.8	6 of 21	28.6
van Dortmont et al. [53]	RCT	24	Thompson cemented unipolar HA	3 AO screws	1 of 29	3.4	4 of 31	12.9
Puolakka et al. [42]	RCT	24	Thompson cemented unipolar HA	Ullevaal screws	1 of 15	6.7	7 of 16	43.75
Current study	Retrospective	45	Cemented bipolar HA	3 cancellous screws	44 of 667	6.6	129 of 339	38.1

RCT = randomized controlled trial; HA = hemiarthroplasty.

fixation were more likely to undergo reoperation. Our reoperation rates for displaced fractures of 38.1% and 6.6% in internal fixation and hemiarthroplasty, respectively, are within the range reported in the literature (Table 6). In a study by Parker et al. [39], reoperation rates were 6.6% for hemiarthroplasty versus 38.1% for internal fixation. We found the same reoperation rates for hemiarthroplasty and internal fixation. The reoperation rate for patients with nondisplaced fractures treated with internal fixation was 15.1% in our study with 45 months followup. This was within the range reported by others (Table 7). Although our rate was much higher than the 11.7% reoperation rate reported by Conn and Parker [13], it was corroborated in the study by Bjorgul and Reikeras [7]. This could be partially attributable to the greater than 90% followup at 1 year, our large sample size, and long-term followup. Furthermore, our study is retrospective, and therefore we

would expect an actual failure rate to be even higher than our findings.

Most reoperations occurred within 1 year and 3 months for the fixation and hemiarthroplasty groups, respectively. Most failures after fixation were attributable to late complications such as nonunion and avascular necrosis. Greater than half of the reoperations after hemiarthroplasty, in contrast, are the result of a short-term complication, infection. Reoperation more than 3 years from the primary surgery occurred in seven of 697 patients (1.0%) after fixation and four of 667 patients (0.5%) after hemiarthroplasty supporting prior reports of relatively few long-term complications of these procedures [39, 45].

Our nonunion reoperation rates of 5.6% and 18.3% for nondisplaced and displaced fractures, respectively, treated with internal fixation, were in keeping with those reported in the literature (Table 8). Rates of reoperation secondary

Table 7. Comparison of current and published studies, nondisplaced

Study	Study type	Followup (months)	Internal fixation	Total cases	Reoperations	Avascular necrosis	Nonunion	Periprosthetic fracture	Superficial infection	Deep infection	Other	Total reoperation rate (%)
Lagerby et al. [31]	RCT	12	Richards or Uppsala screws	75	11	9	2	0	0	0	0	14.7
Phillips and Christie [40]	Prospective	41	Watson-Jones nail	72	7	1	4	0	0	0	2	9.7
Gjertsen et al. [22]	Prospective	12	Olmed screws, Hansson pins, cancellous screws	4310	436	0	0	0	0	0	0	10.1
Hui et al. [25]	Prospective	6	Sliding hip screw	29	9	1	0	0	0	0	8	31
Chen et al. [11]	Prospective	6	Cancellous screws	37	6	4	2	0	0	0	0	16.2
Bjorgul and Reikeras [7]	RCT	38	2 Olmed screws	225	42	10	16	2	0	1	13	18.7
Conn and Parker [13]	Prospective	15	3 cancellous screws	375	45	15	24	1	0	0	5	11.7
Doran et al. [15]	RCT	29	2 hook pins	58	6	4	0	0	0	0	2	10.4
Barnes et al. [4]	Prospective	36	Crossed screws, Smith-Petersen nail, or nail plate	295	11	9	2	0	0	0	0	4.1
Current study	Retrospective	45	3 cancellous screws	358	54	9	20	6	0	0	19	15.1

Categories marked with 0 were either stated as 0 or not reported; the definition of early loss of reduction was variable in each report. Some included this type of failure as nonunion; RCT = randomized controlled trial.

Table 8. Comparison of studies of complications with displaced fractures

Study	Treatment	Total/ reoperation	Complications		Early loss of reduction	Prominent screws/screw protrusion	Dislocation	Component loosening
			AVN	Nonunion				
Frihagen et al. [18]	2 cancellous screws	111/47	6	40	0	3	6	0
Parker et al. [39]	Bipolar cemented	108/11	0	3	0	0	1	1
	3 AO screws	226/86	11	78	0	0	2	3
Davison et al. [14]	Uncemented Austin Moore	229/15	0	2	0	0	1	10
	AMBI compression hip screw and two-hole plate	93/28	8	22	14	0	0	0
	Thompson HA or cemented bipolar HA	187/6	0	0	0	0	3	0
Bjorgul and Reikeras [6]	Olmed screws	228/54	8	35	1	0	0	0
	Exeter cemented HA	455/9	0	0	0	0	5	0
Blomfeldt et al. [10]	2 cancellous screws	30/10	0	8	0	1	0	0
	Uncemented Austin Moore	30/4	0	0	0	0	0	0
Roden et al. [44]	2 von Bahr screws	52/34	10	7	9	3	0	0
Soreide et al. [47]	Varikopf bipolar HA	47/8	0	0	0	0	7	0
	von Bahr screws	51/9	2	11	0	0	0	0
Svenning-sen et al. [50]	Christiansen bipolar HA	53/5	0	0	0	0	5	0
	Compression screw or McLaughlin nail plate	110/16	17	25	5	0	0	0
van Vugt et al. [54]	Christiansen bipolar HA (cementation unknown)	59/8	0	0	0	0	0	0
	Dynamic hip screw	21/6	2	4	0	0	0	0
van Dortmont et al. [53]	Cemented bipolar HA	22/7	0	0	0	0	0	2
	3 AO screws	31/4	0	5	2	0	0	0
	Thompson cemented unipolar HA	29/1	0	0	0	0	0	0
Puolakka et al. [42]	Ullevaal screws	16/7	2	5	1	0	0	0
	Thompson cemented unipolar HA	15/1	0	0	0	0	1	0
Current study	3 cancellous screws	339/129	19	62	18	18	0	0
	Cemented bipolar HA	667/44	0	0	0	0	6	5

Table 8. continued

Study	Acetabular erosion	Periprosthetic fracture	Hematoma	Superficial infection/ wound dehiscence	Deep infection	Heterotopic ossification	Other
Frihagen et al. [18]	0	0	0	0	7	1	0
Parker et al. [39]	0	0	0	2	7	1	0
	0	6	2	9	0	0	0
	1	2	0	0	0	0	0
Davison et al. [14]	0	0	0	0	0	0	0
	3	0	0	0	1	1	2
Bjorgul and Reikeras [6]	0	9	0	0	1	0	0
	0	2	0	0	2	0	0
Blomfeldt et al. [10]	0	1	0	0	0	0	0
	0	4	0	1	2	0	0
Roden et al. [44]	0	0	0	2	1	0	0
	0	0	0	0	1	5	0
Soreide et al. [47]	0	0	3	2	0	0	0
	0	0	1	3	1	0	0
Svenning-sen et al. [50]	0	0	0	0	2	0	0
	0	7	0	1	3	0	0
van Vugt et al. [54]	0	0	1	0	0	0	0
	3	0	1	2	0	0	0
van Dortmont et al. [53]	0	0	0	0	0	0	0
	0	3	3	5	0	0	0
Puolakka et al. [42]	0	0	0	0	0	0	0
	0	0	0	0	0	0	0
Current study	0	7	2	0	5	1	0
	0	4	2	3	23	0	0

AVN = avascular necrosis; HA = hemiarthroplasty; categories marked with 0 were either stated as 0 or not reported; the definition of early loss of reduction was variable in each report. Some included this type of failure as nonunion.

to avascular necrosis in our patient population were 2.5% and 5.6% for nondisplaced and displaced fractures, respectively. These rates are also consistent with rates in prior reports (Table 8). Ten percent of the nondisplaced group and 30% of the displaced group underwent a moderate reoperation (Table 5). This challenges the view that reoperations of failed fixation procedures are minor. Fixation failures may be explained by an elderly patient's bone quality, disruption of vascular supply, and inherent instability of displaced fractures [12, 40]. A total of 6.6% of displaced fractures treated with hemiarthroplasty underwent reoperation; deep infection (3.4%) was the leading cause. Our infection rate is within previously reported rates ranging from 0% to 18% reported by Bhandari et al. in their meta-analysis [5]. Absent from our list of complications leading to reoperation is acetabular erosion. Haidukewych et al. [24] reported similar results in a long-term survivorship study with one case of acetabular erosion in 212 hemiarthroplasties.

Increasing evidence supports the use of hemiarthroplasty over internal fixation in an elderly population with FNFs. Although hemiarthroplasty is not without its complications, the data indicate a lower failure rate with fewer reoperations, lower contralateral fractures, and overall lower costs with its implementation. Furthermore, our reoperation rate of 15.1% for nondisplaced fractures suggests that uncomplicated healing with treatment by fixation is not universal and that one of every seven patients can expect to undergo a second operation.

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