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Literature Review

What is the impact of age on reoperation rates for femoral neck fractures treated with internal fixation and hemiarthroplasty? A comparison of hip fracture outcomes in the very elderly population

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ABSTRACT

Methods: A retrospective comparative study was performed at a level 1 trauma center at which electronic medical records and digital radiographs were reviewed for 949 femoral neck fractures. For the primary outcome of reoperation based on age, Kaplan–Meier models were built and analysis applied.

Results: A total of 334 fractures were nondisplaced treated with closed reduction and percutaneous pinning (CRPP), and 615 were displaced managed with hemiarthroplasty (HA). Overall, 98 patients (10.33%) required reoperation. Increasing reoperation rates for CRPP was seen with each subsequent age group. The opposite was seen with HA in which increasing age groups showed lower reoperation rates.

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1. Introduction

Average age in the United States is increasing, with the number of people older than 65 expected to increase from 37.1 million to 77.2 million by the year 2040.^{1,2} The rate of hip fractures is expected to double, with an estimated 6.3 million projected by 2050 worldwide.^{1,2} Femoral neck fractures (FNF)

account for nearly 50% of all hip fractures.³ Mortality rates one year after a hip fracture range from 14% to 36% among the elderly population.^{4,5}

Patient's age, activity, comorbidities, functional demands, and the perceived risk of secondary surgery are important factors that can alter treatment.⁶ Elderly patients have medical conditions that can place them at high risk for anesthesia and surgery related complications.⁴ Ambulatory and functional

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Abbreviations: FNF, femoral neck fractures; CRPP, closed reduction and percutaneous pinning; HA, hemiarthroplasty; AVN, avascular necrosis; THA, additional treatment options.

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status are important, with only 50–65% of patients able to regain their pre-fracture walking status.^{5,7} Secondary surgery leads to increased patient morbidity and higher costs to our health care system.⁸

The preferred method of surgical intervention for FNF remains a topic of debate. Closed reduction and percutaneous pinning (CRPP) and hemiarthroplasty (HA) are the most commonly performed surgical interventions for FNF in the elderly population. CRPP is used more frequently for non-displaced FNF and has been associated with decreased blood loss, less operative time, and shorter hospital stays.^{9,10} However, when CRPP has been used for displaced FNF, it has been associated with high rates of reoperation leading to inferior cost effectiveness.^{11–15} Arthroplasty (HA and total hip arthroplasty) has shown better initial postoperative skeletal stability and lower rates of failure leading to fewer reoperations.^{10,16,17} Arthroplasty also has been associated with increased surgical morbidity and a trend toward increased mortality in studies among the elderly population above 60 years of age.^{3,8,10,12,18}

Extensive research of FNF has primarily compared outcomes of treatment methods within the elderly population.^{2,6,12,19–23} Discussed in a review of FNF by Miyamoto et al. specific age among the elderly is a critical factor not considered in most of the literature. Thus, a definitive evidence-based judgment across age groups cannot be made regarding the best treatment approach.⁴ One specific population of importance is that of octogenarians (patients ≥80 years of age). A literature search reveals that there are only two studies looking at surgical outcomes after FNF treatment in the octogenarian population, and these two studies arrived at different conclusions.^{7,17} The present study aims to assess the effect of age on reoperation rates following FNF treated with CRPP and HA by using a large hip fracture database. Secondary aims were to examine reasons for reoperation and to assess mortality within each age group for the two treatment methods.

2. Materials and methods

Following approval by our institutional review board, we conducted a retrospective, comparative chart review at a level one trauma center. We included all FNF's in patients aged 60 years or greater who underwent surgical intervention from 1998 to 2009. Our exclusion criteria included trauma beyond a simple fall from standing, concurrent neoplasia, extracapsular hip fracture (OTA/AO 31-B2.1), prior surgery to ipsilateral proximal femoral region, and treatment other than CRPP for nondisplaced FNF or HA for displaced FNF. In addition, we required a minimum of 2 year follow-up and included patients who died or had reoperation within the first 2 years post operatively. Death records were obtained from Texas Vital Statistics based on date of birth, name and sex. We defined reoperation as any operation performed due to complications of the primary procedure.

Fracture displacement was categorized as nondisplaced or displaced by two methods. Digital radiographs were available after August of 2002. These fractures were identified as nondisplaced if they were AO/OTA 31B1.1-3 (Garden 1 & 2)

or displaced if they were 31B3.1-3 or 31B2.2-3 (Garden 3 & 4). Radiographs were reviewed and confirmed by two orthopedic residents, Dr. Kip Murphy and Dr. Timothy Randell. For fractures occurring prior to 2002, displacement classification was discerned through review of orthopedic and radiologic records.

Patients who received CRPP underwent closed reduction on a fracture table and implant placement as described by Probe et al. using ASNIS III (Stryker, Kalamazoo, MI, USA) 6.5 mm cannulated screws.²⁴ The decision to place 3 or 4 screws was based on surgeon preference. HA was performed using a Harding lateral approach combined with a modular stem utilizing third-generation cementing techniques.

A database of 914 patients treated with CRPP for non-displaced fractures or HA for displaced fractures from 1998 to 2009 met our inclusion criteria. There were a total of 949 FNF; with 334 nondisplaced and 615 displaced fractures. Other information included for analysis were patient age, sex, surgery performed, fracture displacement, and dates of last contact or death note. Age groups of 60–69, 70–79, and ≥80 were created within nondisplaced fractures treated with CRPP and displaced fractures treated with HA. The primary outcome measure was reoperation rates of each treatment method overall, by age groups and at different post-operative time intervals. Secondary outcome measures were reasons for failure and mortality.

Reoperation reasons were classified according to the primary etiology determined from review of the orthopedic and radiographic records. Reasons for reoperation included nonunion, avascular necrosis (AVN), prominent hardware requiring removal, femoral head screw protrusion, deep infection, superficial infection, hematoma, periprosthetic fracture, femoral component loosening, heterotopic ossification, dislocation, acetabular erosion and early loss of reduction. Displacement prior to 3 months postoperatively without radiographic evidence of healing was defined as early loss of reduction.

2.1. Statistics

Demographic data of three age groups as well as data describing injury, surgery type, and reoperation were summarized using means and percentages, as appropriate. Overall reoperation rates were compared between surgical groups using a chi-squared test.

Kaplan–Meier models were built and analyzed using Cox regression, to understand: (a) differences in reoperation rates between age groups within the CRPP treated patients; (b) differences in reoperation rates between age groups within the HA treated patient; and (c) differences in reoperation rates between surgery types within each age group. The same analyses were done for mortality.

To understand how age and surgery choice interact a Kaplan–Meier model was built for reoperation including as covariates age, surgery, and an interaction term. The same was done for mortality. Finally, a Woolf test was carried out to determine whether odds-ratios (CRPP versus HA) for reoperation within two years differ by age group. The same was done for two-year mortality.

3. Results

Among the charts reviewed, 914 patients (949 FNFs) met our inclusion criteria. Of those reviewed, 213 (23.3%) were male and 701 (77.13%) were female. Age of subjects was well distributed with an average age of 81.5 years. There were 75 (7.9%), 268 (28.24%), and 606 (63.86%) patients in their 60s, 70s, and ≥80s, respectively. Gender did not significantly differ between displaced FNF and nondisplaced FNF groups. Overall mortality rate at one year postoperatively was 25.08% (238 patients). Mean follow-up time was 1186 days with a median of 1016 days. This follow-up time includes all patients who died and had reoperation.

Of the 949 fractures, 334 (35.19%) were nondisplaced treated with CRPP and 615 (64.81%) were displaced treated with HA. Overall, a total of 98 patients (10.33%) required reoperation. Reoperation rates did differ significantly by chi-squared analysis ($p < 0.001$) between the two treatments at two-year follow-up with 49 (14.67%) patients treated with CRPP requiring reoperation and 39 (6.34%) patients treated with HA requiring reoperation. For CRPP, 32 (16.49%) patients 80 years or older required reoperation, while only 3 (9.38%) in the 60–69 age group required reoperation within 2 years. For HA, 20 (4.85%) patients 80 years or older required reoperation while 7 (16.28%) in the 60–69 age group required reoperation within 2 years. The 70–79 age group showed intermediate reoperation rates with 14 (12.96%) in the CRPP group and 12 (7.5%) in the HA group (Table 1). Increasing reoperation rates for CRPP were seen with each subsequent age group. The opposite was seen with HA in which increasing age groups showed lower reoperation rates (Fig. 1). The relationship of reoperation rate with surgical choice changing by age group was found to be significant by Woolf test ($p = 0.028$).

A Kaplan–Meier survival analysis compared reoperation rates across age groups within nondisplaced FNF treated with CRPP. For these patients, the overall implant survival rates were 97.9%, 91.5%, 85.7%, 82.8%, and 80.9% at 1 month, 6 months, 1 year, 2 years, and 3 years, respectively. Implant survival rates were then further analyzed by the age groupings previously described. Overall reoperation rates were not found to be statistically significant. A significant difference in reoperation was found at 6 months for 60s versus 70s ($p = 0.003$) and 60s versus ≥80 ($p = 0.013$). In addition, a significant difference was found with the 60s versus ≥80 at 1 month ($p < 0.001$). These showed consistently higher reoperation for older age groups. No further difference was found in reoperation rates between the 3 age groupings at 1 month, 6 months, 1 year, 2 years, and 3 years in regards to nondisplaced FNF treated with CRPP.

A similar Kaplan–Meier survival analysis was used to compare reoperation rates across age groups within HA. For

Fig. 1 – Reoperation rates at two-year follow-up of CRPP versus HA by age groups.

displaced FNF treated with HA, the overall implant survival rates were 96.2%, 93.8%, 93.6%, 92.9%, and 92.6% at 1 month, 6 months, 1 year, 2 years, and 3 years, respectively. When further analyzed by age groups, higher reoperation rates were seen in the younger age groups with a significant difference being found at 6 months and 1 year with regard to the 60s versus ≥80 ($p = 0.038$, $p = 0.044$). Overall reoperation rates were found to be significantly different ($p = 0.011$).

Reoperation rates were compared between CRPP and HA for each age grouping. For the 60s age group, there was a significantly higher rate of reoperation in HA at 1 month ($p = 0.035$) and 6 months (0.004). In the 70s age group there was no significant difference. In the ≥80 group, an opposite difference of reoperation rates was seen at 6 months ($p = 0.038$), 1 ($p < 0.001$), 2 ($p < 0.001$), and 3 ($p < 0.001$) year follow-up with rates of CRPP reoperation consistently higher (Fig. 2). The proportional hazard of reoperation for HA versus CRPP in the octogenarians was 0.28 (95% CI 0.16–0.48, $p < 0.001$).

There were a total of 54 (16.17%) FNF treated with CRPP requiring reoperation (Table 2). The most common reason for reoperation was nonunion which occurred 5.1% ($n = 17$) of the time and accounted for 31.5% of reoperations in this group. AVN and prominent hardware were second, each occurring 3.3% ($n = 11$) of the time. The other three reasons for reoperation were early loss of reduction (2.1%, $n = 7$), screw protrusion into acetabulum (0.6%, $n = 2$) and periprosthetic fracture (1.8%, $n = 6$).

Displaced FNF treated with HA required reoperation in 44 (7.15%) fractures. Deep infection was the most common reason for reoperation occurring 3.9% ($n = 24$) of the time. All other reasons occurred less than one percent of the time and included; dislocation (0.97%, $n = 6$), femoral component loosening (0.65%, $n = 4$), periprosthetic fracture (0.49%, $n = 3$), superficial infection (0.49%, $n = 3$), hematoma (0.33%, $n = 2$),

Table 1 – Reoperation rate by age group and treatment at 2-year follow-up.

	60–69	70–79	≥80
CRPP	3/32 (9.38%)	14/108 (12.96%)	32/194 (16.49%)
HA	7/43 (16.28%)	12/160 (7.5%)	20/412 (4.85%)

Fig. 2 – Reoperation of CRPP versus HA within the octogenarian population.

heterotopic ossification (0.16%, $n = 1$), and acetabular erosion (0.16%, $n = 1$).

Mortality data were analyzed with an overall one-year mortality of 25.08% (238 patients). As expected, mortality was found to be higher with the older age groups. By Kaplan-Meier survival analysis, there was no significant difference between CRPP and HA in regards to mortality within the 60s and 70s age groupings. Statistically significant differences in mortality among the octogenarians were seen at 6 month ($p = 0.022$), 1 year ($p = 0.015$), 2 year ($p = 0.014$), and 3 year ($p = 0.041$) follow-up with HA showing higher mortality than CRPP. There was no difference in mortality observed at 1-month follow-up. Additional analysis was performed with the Woolf test in order to determine if the relationship of one-year mortality with

surgical choice changes by age. There was no significant difference in mortality by using Woolf test ($p = 0.13$).

4. Discussion

FNF are a common injury and the preferred method of surgical intervention remains a topic of debate. A lack of evidence exists for treatment guidance based on age among the elderly, and the small amount of data in the literature is conflicting. Our study primarily analyzed reoperation rates of specific age groups following FNF treated with CRPP versus HA. In addition, we examined reasons for reoperation and assessed mortality for the two treatment methods. The unique design of the present study with the large patient population allows one to focus on the impact of specific age groups, in particular the octogenarian population.

We caution readers on the inherent limitations of our study. Our study was a retrospective analysis, which prevented us from including variables in our data collection such as pre-operative mental and functional status. The cognitive status of a patient could have a direct effect on how well a patient tolerates the post-operative period, which ultimately could affect reoperation rates.^{25,26} Functional status has been shown to increase complications such as periprosthetic fracture and acetabular wear, both of which require a reoperation.¹⁷⁻³⁰ Though we could not include these factors, the large sample size helped to offset the exclusion of these variables. Secondly, our population consisted of both non-displaced FNF and displaced FNF, which may present confounding factors. Third, surgeon bias inevitably is present in clinical practice and the selection of the appropriate surgical procedure. However, in our study, this potential concern is dampened by the large patient population and exclusion criteria. Fourth, our study did not investigate further patient related factors such as bone quality, medical comorbidities, and inclusion of additional treatment options (THA). It has been well documented that the use of THA in a healthy patients is associated with better hip function scores, quality of life, and lower reoperation rates compared to CRPP.^{2,8,22,23,31-34} Fifth, length of follow-up is an additional potential limitation of our study. Common causes of hemiarthroplasty revision, such as femoral component loosening and acetabular erosion can take years to develop. With an average follow-up time of just over 3 years, some of these complications likely fell outside our included follow-up. Despite this potential limitation, Parker et al. reported minimal re-operation rates in HA's following the initial 3 year post-operative window with an average follow-up time of 9 years. Finally, the infection rate in the HA group was 3.9%. Lower infection rates following HA have been reported, which could artificially elevate the failure rate of HA. However, Ridgeway et al. reported in a prospective study of 5769 HA an infection rate of 4.97%.³⁵

Chen et al. (2005) analyzed the failure rate of nondisplaced FNF treated with CRPP in patients over 80 years of age. In their study of thirty-seven octogenarian patients, they showed an overall failure rate of 16.22% (6 patients) at 2-year follow-up. Their study did not compare this failure rate to those of different age groups or different treatment options such as HA. Chen et al. came to the overall conclusion that CRPP is an

Table 2 – Reasons for reoperation of CRPP and HA by age groupings.

	CRPP (60s, 70s, ≥80)	HA (60s, 70s, ≥80)
Nonunion	17 (1, 5, 11)	0
AVN	11 (2, 3, 6)	0
Prominent hardware	11 (0, 4, 7)	0
Deep infection	0	24 (5, 5, 14)
Periprosthetic fracture	6 (0, 0, 6)	3 (0, 2, 1)
Heterotopic ossification	0	1 (0, 1, 1)
Dislocation	0	6 (1, 2, 3)
Femoral component loosening	0	4 (0, 3, 1)
Loss of reduction	7 (1, 1, 5)	0
Hematoma	0	2 (1, 0, 1)
Superficial infection	0	3 (0, 1, 2)
Screw protrusion into acetabulum	2 (0,1,1)	0
Acetabular Erosion	0	1 (0,1,0)

effective procedure for the treatment of nondisplaced FNF in patients older than 80 years.³⁶ Our study's reoperation rate at 2-year follow-up of 16.49% for nondisplaced FNF treated with CRPP in octogenarians was similar to that reported by Chen et al. Unlike their study, we compared reoperation rates of 949 FNF within 3 age groups treated with CRPP or HA. The larger patient population allowed the analysis to show that the 16.49% reoperation rate in octogenarians treated with CRPP is high compared to a HA reoperation rate of 4.85% in patients of comparable age.

Hui et al. (1994) compared reoperation rates after CRPP of nondisplaced FNF in octogenarians to similar fractures in patients aged 65–79 years and an age matched control group consisting of displaced FNF treated with HA. Their study consisted of 29 octogenarians treated with CRPP, and the associated matched groups. They found a significantly greater proportion of octogenarians treated with CRPP required reoperation (31%) and came to the conclusion that octogenarians with nondisplaced FNF should be treated with primary HA for early mobilization. Our study, with a larger patient population, found similar patterns in regard to reoperation rates. In the present study, 32 patients (16.49%) over the age of 80 treated with CRPP required reoperation while 3 (9.38%) in the 60–69 age group treated with CRPP required reoperation. Octogenarians with displaced FNF treated with HA had 20 (4.85%) reoperations. The proportional hazard of reoperation in octogenarians treated with HA compared to CRPP of 0.28 ($p < 0.001$) shows the risk of reoperation to be nearly four times greater for CRPP versus HA.

Gjersten et al. (2010) compared 4335 patients over the age of 70 with displaced FNFs following treatment with CRPP or HA. Their study evaluated one-year mortality, number of reoperations, and patient self-assessment of pain, satisfaction, and quality of life. They found no statistical significance in one-year mortality in the two treatment arms (27% in CRPP and 25% in HA). Reoperation rates in the CRPP and HA groups were 22.6% and 2.9%, respectively, thus concluding the elderly should be treated with hemiarthroplasty. While our study measures similar variables, we expanded on these numbers by including patients in the 60–70 year age range and exclusively evaluated non-displaced fractures in the CRPP treatment arm. Our study's reoperation rate in the CRPP group >70 averaged 14.73% and 6.18% in the HA group. Additionally, we found a significantly lower reoperation rate in the CRPP group (9.38%) and conversely higher rate in the HA group (16.28%) in the younger demographic.

Secondary surgery leads to increased morbidity to patients and higher cost to our health care system.⁸ Our study shows increasing reoperation rates for CRPP as age increases. The opposite was seen with HA, where increasing age corresponded to lower rates of revision. The increase in reoperation rates in CRPP versus HA has been noted by Parker et al. (2008), but was not further investigated by age groups.¹⁰ Prominent hardware from collapse or femoral head screw protrusion was the most common reason for reoperation in our CRPP treatment group. Fixation failures may be explained by the elderly patients' bone quality, disruption of vascular supply and inherent instability of fractures.^{16,24} Displaced FNF treated with HA required reoperation in 7.15%, with deep infection being the most common reason. Our infection rate of 3.9% is

comparable to previously reported rates that have ranged from 0% to 18%.¹⁹

A valid argument exists that there are minor versus major reoperations, and it has been suggested that despite higher reoperation rates seen in CRPP, many are minor reoperations.²⁶ Attempts have been made to classify reoperations into minor, moderate, and major categories based on the secondary procedure.²⁰ Murphy et al. utilized this classification in a recent study of reoperations of CRPP and HA in 1411 patients.³⁶ They found that reoperations were classified as moderate or major in over 90% of HA and 80% of CRPP treated patients. In our study, eleven cases were due to prominent hardware requiring removal and would be classified as minor. Three of these patients who underwent removal of hardware ultimately required conversion to arthroplasty. All other reoperations in the CRPP group (78%) required a moderate to major reoperation. Gjersten et al. demonstrated that in patients who received HA as a secondary surgery compared to primary HA, showed more dissatisfaction, pain, and lower quality of life.³⁷

Mortality rates one year after a hip fracture range from 14% to 36% among the elderly population.^{4,5} In our study, the mortality rate at one year postoperatively was 25.08% (238 patients). Published literature has supported both no difference in mortality between CRPP and HA, as well as lower mortality with CRPP.^{3,8,10,12,18,21,22,38–40} Our study showed no significant difference between CRPP and HA in regards to mortality within the 60s and 70s age groupings. In the octogenarian group, the mortality was higher in the HA versus CRPP at 6 month, 1 year, 2 year, and 3 year follow-ups, but this difference was not observed at 1-month follow-up. This may suggest that the difference in mortality is not due to surgical preference, with no difference seen in the acute postoperative period. In addition, when the data were further analyzed using the Woolf test the relationship between age groups in terms of death rate does not differ by surgery type. Further study is warranted to determine possible underlying cause of the change in mortality seen.

Octogenarians with nondisplaced FNF pose a unique set of challenges compared to their younger counterparts. This study indicates that the reoperation rate in patients over 80 is high when treated with CRPP and low with HA compared to younger age groups. In addition, our study showed a higher reoperation rate in the 60–70 age population treated with HA with no significant difference in mortality. Consideration of CRPP or total hip arthroplasty in this more active demographic is necessary. Mortality rates are high in the hip fracture population and individual patient consideration needs to be made, however, we did not find significant differences in mortality rate in the acute postoperative period. These factors should be considered by the surgeon when planning treatment for FNFs. Future studies are warranted to investigate the effect on these patient factors with reoperation and mortality. A randomized control trial comparing HA and CRPP in non-displaced FNF within the octogenarian population is needed to further investigate the current study's findings.

Conflicts of interest

The authors have none to declare.

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