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HIP ARTHROPLASTY

Does surgeon volume influence the outcome after hip hemiarthroplasty for displaced femoral neck fractures; early outcome, complications, and survival of 752 cases

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Abstract

Introduction Surgeon volume of hip arthroplasties is of importance with regard to complication and revision rates in total hip arthroplasty. For hip hemiarthroplasty, the effect of surgeon volume on outcome is far less studied. We analyzed the outcome of hip hemiarthroplasties performed by orthopedic surgeons in a retrospective cohort in different volume categories, focusing on early survival of the prosthesis and complications.

Methods Between March 2009 and January 2014, 752 hemiarthroplasties were performed for intracapsular femoral neck fracture by 27 orthopedic surgeons in a large Dutch teaching hospital. Surgeons were divided into four groups, a resident group and three groups based on the number of total hip arthroplasties and hemiarthroplasties performed per year: a low-volume (< 10 arthroplasties per year), moderate-volume (10–35 arthroplasties per year), and high-volume groups (> 35 arthroplasties per year). Outcome measures were stem survival using a competing risk analysis, complication rates, and mortality. Chi-square tests were used to compare complication rates and mortality between groups.

Results Patients were followed for a minimum of 2 years or until revision or death. Overall 60% of the patients included had died at time of follow-up. We found comparable stem survival rates in the low-volume group ($n = 48$), moderate-volume group ($n = 201$), high-volume group ($n = 446$), and resident group ($n = 57$). There were no significant differences between the groups with regard to dislocation rate, incidence of periprosthetic fracture, infection, and mortality.

Conclusion Surgeon volume and experience did not influence early outcome and complication rates in hip hemiarthroplasty. Hemiarthroplasty can safely be performed by both experienced hip surgeons and low-volume surgeons.

Keywords Hip hemiarthroplasty · Femoral neck fractures · Surgical volume · Survival · Complications

Introduction

Femoral neck fractures are common in traumatology in the elderly and the occurrence of this injury is expected to increase in the following decades [1, 2]. The most suitable choice for the majority of this patient group is a hemiarthroplasty [3]. Across and within different countries, these are performed by different types of surgeons: general surgeons, trauma surgeons, general orthopedic surgeons, and orthopedic surgeons specialized in hip surgery. As a direct result, the experience with hip arthroplasty differs a lot between surgeons.

Surgeon volume has previously shown to have an effect on outcome in many general surgical [4, 5] and orthopedic procedures, like total knee- and total hip arthroplasty (THA) [6–10]. The previous research showed a higher revision risk after THA performed by low-volume surgeons [9] and a lower risk for dislocation and early revision with higher volume surgeons [10]. Differences in surgeon experience have also been studied in several types of surgery for acute proximal femoral fractures [11, 12]. However, experience

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of a surgeon in general does not reflect the exact volume in hip arthroplasties, which might be the most important factor.

There has been little research on surgeon volume in hip hemiarthroplasty, with almost no information about orthopedic complications and survival [13, 14]. One study [15] showed the effect of surgeon volume for hemiarthroplasty in a Medicare population and concluded worse outcomes regarding complications and mortality for low-volume surgeons. However, these differences were only found between the lowest volume group (0 THAs/year) and the highest volume group (> 25 THAs/year). Remarkably, they found a significant increased risk of revision in the high-volume group compared to the lowest volume group [15]. Hence, clear evidence for a direct relationship between surgical volume and outcome in hemiarthroplasty is not obvious yet.

The aim of the current study was to determine whether there is an association between surgical volume or experience and stem survival, complication rates, and mortality in hip hemiarthroplasties performed in a non-academic teaching hospital. For adequate comparison with the previous studies, outcome measures were compared between low-volume, moderate-volume, and high-volume hip surgeons, as well as a group of orthopedic trainees. We hypothesized that high-volume surgeons would have better outcomes after hemiarthroplasty for femoral neck fracture compared to low-volume surgeons and residents.

Patients and methods

Study population and design

In this retrospective cohort study, all consecutive patients who were operated between March 2009 and January 2014 were included. During this period, 752 hemiarthroplasties for intracapsular femoral neck fracture were performed by 27 orthopedic surgeons, residents, and fellow orthopedic surgeons in one large teaching hospital. Exclusion criteria were pathological fracture and hemiarthroplasty after failed internal fixation procedures. Data were collected from the electronic patient record (Epic Systems Corporation), and to ascertain correct survival data, implant data were compared with data from the nationwide arthroplasty register on completeness. The national population register was also consulted for the most recent data on mortality and date of death. Surgeons were divided into four groups, based on the previous studies [10, 14]. Based on the number of total hip arthroplasties plus hemiarthroplasties per year in the same time period, the orthopedic surgeons were divided into either the low-volume group (less than 10 arthroplasties per year), the moderate-volume group (10–35 arthroplasties a year), or the high-volume group (more than 35 arthroplasties a year). As this study was conducted in a large teaching hospital, the fourth research group was defined as 'residents and fellow orthopedic surgeons', hereinafter referred to as 'resident group'. Details of the four different groups studied are shown in Table 1. Patient demographics including age, gender, side of the surgery, and ASA classification were collected. In addition, the prosthesis type, type of cementation, and the surgical approach were documented (Table 1). Patients were followed for a minimum of 2 years or until revision or death. Patients, who were lost to follow-up, were analyzed as censored data.

Surgical technique

The type of surgical approach used was surgeon based. The posterior approach was used in 518 hips (69%), the anterolateral approach in 184 hips (24%), and the direct lateral approach in 50 hips (7%). In addition, choice of implant was by surgeon's preference. In most cases (89%), an uncemented implant was used. The Accolade HFx Stem (Stryker Orthopedics, Mahwah, USA) was used as the standard uncemented implant for hemiarthroplasty and was used in 491 hips. As the Accolade HFx is only available in limited stem sizes, the Accolade TMZF (Stryker Orthopedics, Mahwah, USA) stem was used as an alternative when pre-operative trial stem placement showed insufficient fixation with the available sizes. The Accolade TMZF stem was used in 186 hips. In 80 hips, a cemented Exeter stem (Stryker Orthopedics, Mahwah, USA) was used because of insufficient stability with an uncemented implant or surgeon preference. All patients followed a standardized postoperative protocol, which allowed immediate full weight bearing.

Data and statistical analysis

For survivorship analysis, we used the cumulative incidence function for competing risk analysis. Since the mortality rate is relatively high in hemiarthroplasty patients, this event can interfere with the event of interest (revision of the prosthesis). The competing risk analysis describes the estimated cumulative incidence (risk over time) of each event type in the presence of the other event types. That is, the risk set attrition due to the occurrence of the competing risk is accounted for when estimating the occurrence of the event of interest [16]. This was conducted in a multivariable analysis to test the association between surgeon volume (3 volume groups and a resident group) and survival of the prosthesis accounting for age and ASA classification. The survival analysis was performed using R (R Foundation for Statistical Computing 2006, Vienna, Austria).

Secondary outcome measures were mortality and orthopedic complications. Baseline statistics were performed using one-way analysis of variance for continuous data and the Chi-square test for categorical data. Statistics for

Table 1 Patient characteristics

	Low-volume group	Moderate-volume group	High-volume group	Resident group	*p* value
Number of patients	48	201	446	57	
Age (SD)	83.2 (7.76)	83.6 (7.43)	83.5 (7.37)	85.6 (5.59)	0.21
Sex (% men)	29.2	26.4	26.7	24.6	0.96
Laterality (% left)	47.9	50.2	54.3	49.1	0.65
Prosthesis (% cemented)	2.1	15.8	8.2	16.9	**0.004**$^{\circ\#¢}$
Approach (%)					**< 0.001**$^{\circ\#¥┼¢§}$
Anterolateral	0.0	31.5	25.3	14.0	**< 0.001**$^{\circ┼¢§}$
Straight lateral	0.0	23.0	0.5	3.5	**< 0.001**$^{\circ\#§}$
Posterolateral	100	45.5	74.2	82.5	**< 0.001**$^{\circ\#┼¢§}$
ASA classification (%)					0.60
1	0	2.5	1.1	0	
2	31.9	17.0	22.9	33.3	
3	68.1	78.5	68.5	63.2	
4	0	2.0	7.5	3.5	

Bold *p* values indicate a significant difference between the groups, and posthoc significant differences are indicated by the symbols in superscript following the *p* value

°Significant difference between groups 1 and 2

#Significant difference between groups 2 and 3

¥Significant difference between groups 3 and 4

┼Significant difference between groups 1 and 3

¢Significant difference between groups 1 and 4

§Significant difference between groups 2 and 4

complications and mortality were performed using the Chi-square test for independence. A *p* value of 0.05 was considered significant, whereas posthoc the *p* value was corrected for multiple comparisons. These statistics were performed using SPSS version 19.0.

Results

Patient characteristics

Patient demographics were similar between the four groups, whereas the number of cemented prosthesis and the surgical approach were statistically different between the groups (Table 1). 17 patients were lost to follow-up, since they lived in a different area of the country and were physically not able to come to the hospital for assessment.

Survival of the prosthesis

Revision of the prosthesis was necessary in 34 hemiarthroplasties (4.5%), with no statistical differences between groups. Reasons for revision were periprosthetic fracture, dislocation, aseptic loosening, and deep infection. Cumulative incidence analysis revealed comparable survival percentages at a mean follow-up at 3.7 years between the groups with survival rates of 95.8% (95% CI 90.1–100) for the low-volume, 93.9% (CI 90.6–97.3) for the moderate-volume, 95.9% (CI 94.0–97.8) for the high-volume, and 96.5% (CI 91.7–100) for the resident groups (Fig. 1). Overall survival rate at 5 years was 95.4% (CI 93.9–96.9). Competing risk regression analysis revealed no effect of volume ($p = 0.68$), accounting for age and ASA (Table 2).

Complications

Dislocation was found in 34 hips (4.5%). There were no significant differences between the research groups (Table 3). Dislocation was successfully treated with closed reduction in 13 cases. In 7 cases, the patient needed open reduction with a tendon tenotomy ($n = 2$), a revision of the stem ($n = 3$) or head exchange ($n = 2$) to increase offset. In four patients, a re-operation was performed in which a dual-mobility cup was placed while maintaining the stem. A Girdlestone hip procedure was necessary in nine patients because of recurrent dislocation in non-instructable patients with poor preoperative ambulant status. These patients mainly suffered from dementia. One patient was treated conservatively, given the state of dislocation for a longer time with limited

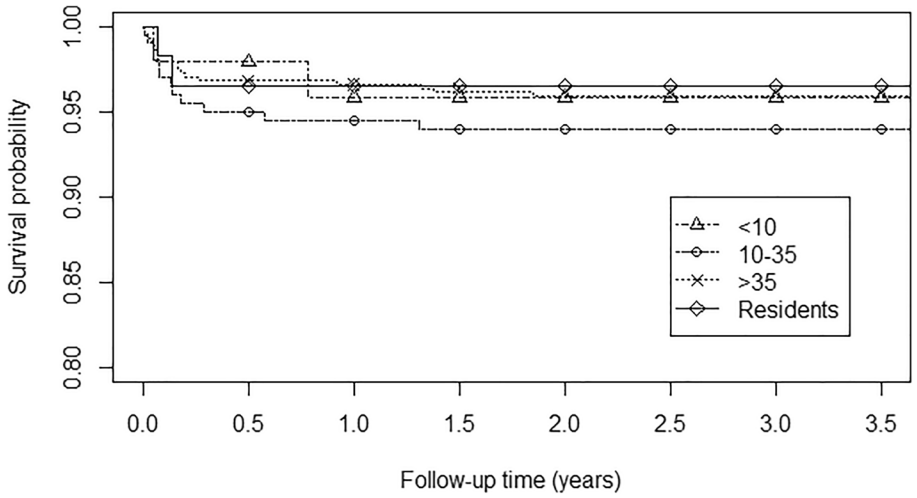

Fig. 1 Survival curve of the four different volume groups with endpoints indicating revision of the prosthesis for any reason

Table 2 Competing risk regression hazard ratios

	Categories	Ratio's (95% CI)	*p* value
Volume	< 10	1	**0.74**
	10–35	1.54 (0.34–7.00)	0.58
	> 35	1.04 (0.24–4.55)	0.96
	Residents	1.02 (0.14–7.46)	0.99
Age	< 75	1	**0.02**
	75–85	0.35 (0.15–0.81)	0.01
	> 85	0.30 (0.12–0.74)	0.01
ASA	I–II	1	**0.69**
	III–IV	1.14 (0.50–2.60)	0.69

The *p* value behind the reference group, indicated by Ratio = 1, is the overall *p* value for that specific parameter

pain complaints. The patient was wheelchair bound and in a very bad state of health.

Periprosthetic fractures were found in 17 patients (2.3%). There were no significant differences between the groups (Table 3). In ten cases (1.3%), a Vancouver type B2 or B3 fracture was found, which required fracture fixation with revision of the implant. Four patients (0.5%) received a plate osteosynthesis for Vancouver type B1 or Vancouver type C fracture. Three patients (0.4%) had a Vancouver type A fracture. One patient was operated with wiring for fixation of the greater trochanter, and two patients were treated conservatively because of a non-displaced Vancouver type A fracture.

Deep infection was found in 22 hips (2.9%). Arthrotomy with debridement and irrigation with implant retention and antibiotics was sufficient in 18 hips. In four hips, the prosthesis needed to be removed for persistent infection, and in all these cases, a Girdlestone situation was accepted. Overall mortality rate of all groups was 60%, with no differences between the groups ($p = 0.07$), as well as after 30 days postoperative ($p = 0.79$) or after 3 months ($p = 0.20$).

Discussion

The current retrospective cohort study demonstrates that there is no effect of surgeon volume or experience on the outcome of hip hemiarthroplasty for displaced femoral neck fracture. Survival of the prosthesis after a mean follow-up of 3.7 years was comparable between the volume groups. In addition, the rate of dislocation, infection, periprosthetic fracture, and mortality did not differ between the low-, moderate-, and high-volume groups. Finally, no differences were found between the resident group and the groups of orthopedic surgeons.

Stem survival was 95.4% at 5 years follow-up in the current study. A previous study of Ames et al. showed a revision

Table 3 Number of orthopedic complications in the four volume groups

	Low-volume group ($n = 48$)	Moderate-volume group ($n = 201$)	High-volume group ($n = 446$)	Resident group ($n = 57$)	*p* value
Dislocation < 90 dgn (%)	1 (2.1)	11 (5.5)	20 (4.5)	2 (3.5)	0.75
Periprosthetic fracture < 90 dgn (%)	2 (4.2)	5 (2.5)	8 (1.8)	2 (3.5)	0.64
Deep infection (%)	1 (2.1)	7 (3.5)	12 (2.7)	2 (3.5)	0.92
Re-operation (%)	5 (10.4)	21 (10.4)	39 (8.7)	6 (10.5)	0.89

rate of 7.9% at 5 years after hemiarthroplasty [15]. Differences in these results can be explained by the fact that we performed a competing risk analysis, in which death is considered as a competing risk in the survival analysis. Longer term follow-up is not relevant for this fragile elderly patient group, since most patients may be deceased within a few years. At final follow-up, 60% of all patients had already died.

Considering the effect of surgical volume on this outcome parameter, the report of Ames et al. [15] revealed that high-volume surgeons (> 25 THAs/year) had a higher rate of revision. However, these differences may be attributed by the differences in co-morbidities between the different volume groups. In our study, there were no differences in ASA between the groups, and in the multivariate analysis, we corrected for ASA classification. Besides, their reason for the discrepancy in survival rate between the low-volume and high-volume groups is that their high-volume surgeons revised their patient for other reasons than treating only dislocation or infection, such as acetabular erosion, of which the low-volume surgeons were expected to experience a larger threshold. This issue might not influence the findings of the current study, since patients who received a hip hemiarthroplasty for acute femoral neck fracture in our hospital return in case of problems standard to a high-volume hip surgeon at the outpatient clinic. Hence, it seems that surgical volume is less of an issue with respect to the prosthesis survival.

The discrepancy between the effect of surgical volume in THA [7–10] and hemiarthroplasty could be explained by the fact that in THA the acetabular cup needs to be inserted, which may be a difficult part of the procedure. Malposition of the cup can increase the risk of dislocation and pain [17]. Another explanation would be the high mortality rate and fragile patient population with patients being less mobile and, therefore, less demanding of the prosthesis and with shorter follow-up [3].

In addition to the survival, the complications after hemiarthroplasty determine a large part of its success. With regard to dislocations, our study did not reveal any differences in dislocation rate between the four groups in contrast to the results of Ames et al. [15]. Overall dislocation rate was 4.5%, which is comparable to the literature, varying between 2 and 13% [3, 15, 18]. The risk of dislocation is found to be increased when using a posterior approach [18], but an adequate posterior repair decreases this risk [18, 19]. These specific details were unable to obtain from the study of Ames et al. [15] and a possible difference in their volume groups might exist. In the current study, all patients received a repair of the posterior structures in case of a posterior approach, which could be the reason that we found no significant differences between the groups.

With regard to infection after hemiarthroplasty, our hypothesis was that this would be influenced by surgeon volume, because the literature describes a higher rate of infection with unexperienced surgeons [20]. However, no effect of surgeon volume was previously studied. The overall infection rate of 2.9% was comparable to the literature [21], and we did not find a difference between the surgeon groups studied. There are many factors that have influence on the outcome of surgical site infection, such as pre-operative antibiotics, increased length of hospital stay, and surgery time, and a prolonged time before surgery is performed [20, 21]. The findings of the current study could be explained by the standardized pre- and postoperative care protocols in our hospital. The occurrence of periprosthetic fractures for surgeon volume in hemiarthroplasty was not described previously, although in THA, no differences are described [10]. Compared with other hemiarthroplasty studies and Scandinavian registries, our periprosthetic fracture rate of 2.3% is within the expected range [22, 23]. It seems that other factors, such as gender, age, and implant design, have more impact on this type of complication [3, 24].

Our mortality rates after 30 days, 3 months, and 5 years showed no differences between the different volume groups. The previous literature showed very different results [13, 14]. Ames et al. [15] did show an association between high-volume surgeons and a lower mortality rate after hemiarthroplasty in their cohort, which could be the effect of a different distribution in volume groups. Our volume groups were created based on the combination of total hip arthroplasties and hemiarthroplasties, whereas the other studies based the groups only on the total amount of hemiarthroplasties.

Since our hospital is an urban teaching hospital, residents and fellow orthopedic surgeons are also performing hemiarthroplasties for femoral neck fractures. The literature describes variable outcomes in complication rate for THA between residents and orthopedic surgeons [25, 26]. Palm et al. described the influence of surgeon's experience and supervision on re-operation rate after hip fracture surgery and concluded that unexperienced surgeons should not operate on patients with a technically demanding proximal femoral fracture. However, in the study of Palm et al. [12], hemiarthroplasty as well as internal fixation methods were studied. To analyze whether there was a difference in outcome between residents or fellow orthopedic surgeons and orthopedic surgeons, we separated the resident group. Our results showed no differences in survival, orthopedic complications, or mortality between the resident group and the orthopedic surgeon groups for hemiarthroplasty. It has to be noted that in the resident group, junior residents are being supervised by a senior resident or an orthopedic surgeon and that the resident group also contained fellow orthopedic surgeons.

A limitation of the current study was the difference in approaches between the groups. This was a retrospective study, and therefore, this could not be avoided. Furthermore, in the literature, it is known that several other factors, such as approach and cementation of the stem are influencing the outcome of a hemiarthroplasty. We did not compare these data, because the goal in this study was to find differences in outcome on surgeon volume, which were not found. We chose a minimum follow-up of 2 years. A longer term stem survival of 5 or 10 years may in general be more discriminating in implant survival data; however, this is not a huge topic in the hip fracture population, where mortality is very common within 5–10 years. Therefore, the length of follow-up was regarded adequate. At last, this is a single-center study and it would be an improvement for the results if it was a multicenter study. However, a major advantage of this is that a lot of parameters that might influence the outcome after hemiarthroplasty were comparable between the volume groups. To improve further research, it is necessary that future reports use standardized categories for volume of the groups to draw more validated conclusions. Most studies use a different kind of volume distribution, which makes it hard to compare results. In our report, we have tried to base our distribution on other studies [10, 14].

In conclusion, the current study demonstrated that surgical volume has no effect on the outcome of hemiarthroplasty in patients with displaced femoral neck fracture. Survival, complications rates, and mortality rates did not differ between the volume groups including orthopedic residents. Hence, hemiarthroplasty can safely be performed by both experienced hip surgeons and low-volume surgeons.

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