Reduced revision rate and maintained function after hip arthroplasty for femoral neck fractures after transition from posterolateral to direct lateral approach

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Background and purpose — The direct lateral (DL) approach to the hip for femoral neck fractures (FNF) has been shown to reduce the rate of dislocation and reoperations. We evaluate the effect of transition from the posterolateral (PL) to DL approach on reoperation and dislocation rates and patients' reported outcome.

Patients and methods — In a prospective cohort study between 2012 and 2015, we enrolled 362 patients (median age 83 years, 70% women, mean follow-up 25 months) with a displaced FNF. The first group of 146 patients were operated using the PL and the second group of 216 patients with a DL approach, after change of our routines. A multivariable Cox regression analysis was used to evaluate factors associated with dislocation and reoperation. A generalized linear model was used to evaluate the functional outcome by comparing WOMAC and Harris hip scores between the 2 groups.

Results — The reoperation rate was reduced from 13% in the PL to 6% in the DL group and the dislocation rate from 13% to 4%. Cox proportional hazard analysis identified the PL approach as the only factor associated with an increased risk of reoperation (hazard ratio = 2.5, 95% CI 1.2–5.2). Age, sex, ASA classification, type of arthroplasty, cognitive dysfunction, or the experience of the surgeon had no effect on the risk of reoperation. Patient-reported outcome was similar between the 2 groups.

Interpretation — In patients with FNF we have reduced the reoperation and dislocation rates by changing the surgical approach used for hip arthroplasty without affecting the patient-reported functional outcome.

Worldwide, the number of femoral neck fractures (FNF) is expected to increase dramatically to reach a figure of 8.2 million in 2050 (Sambrook and Cooper 2006). The outcome in this fragile patient group has improved by optimizing the perioperative care and a shift from fracture reduction and fixation to hip arthroplasty.

The 2 most commonly used surgical approaches in hip arthroplasty are the direct lateral (DL) and the posterolateral (PL) approaches. The treating surgeon usually makes the choice of approach used. Previous studies have linked the DL approach to a reduced dislocation rate and need for revisions compared with the PL approach (Enocson et al. 2008, 2009, Sköldenberg et al. 2010, Leonardsson et al. 2012, Rogmark et al. 2014). However, the DL has also been associated with insufficiency of the hip abductors, limping, and lateral thigh pain (Sayed-Noor et al. 2016). The results of these studies have encouraged surgeons to change their approach in FNF patients from the PL to the DL approach. However, the influence of surgical approach on hip function and quality of life in FNF patients has been highlighted in only a limited number of publications (Parker 2015, Leonardsson et al. 2016, Mukka et al. 2016, Kristensen et al. 2017) and there are very few studies that have reported the implication of a routine change on the outcome (Sköldenberg et al. 2010).

Therefore, we investigated the influence of a transition at our department from the PL approach to the DL approach in FNF treated with hemiarthroplasty (HA) and total hip arthroplasty (THA) on the reoperation and dislocation rates and patient-reported outcome (PROM).

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Patients and methods

Study setting

This prospective observational cohort study was conducted between February 2012 and May 2015 at Sundsvall Hospital, Sweden. Sundsvall Hospital is an emergency regional hospital affiliated with Umeå University with a catchment area of approximately 160,000 inhabitants.

Study subjects

All patients with an FNF admitted during the inclusion period and treated with hip arthroplasty were included in the study. Patients living outside the catchment area of Sundsvall hospital, with pathologic fractures, arthroplasty as a secondary procedure after internal fixation, and non-Swedish-speaking patients were excluded. The routine at our department is to perform hip arthroplasty for displaced FNF in patients with age above 60–65 years of age. THA is used in the relatively young (up to 79 years) and active patients, in those with rheumatoid or osteoarthritic changes in the affected hip. HA is used in older (> 79) less active patients, those with low demands, short expected lifespan, and those with cognitive dysfunction. The final decision on whether to choose a THA or HA was made by the treating surgeon according to preference and patient's level of activity.

Data collection and follow-up

By using the unique Swedish personal ID number, we collected data prospectively throughout the study period by searching our in-hospital medical database. All patients without exclusion criteria and treated for displaced FNF (ICD-10 S72.00) were included. Information regarding surgical approach, the surgeon's experience (resident or consultant), surgical time, comorbidities registered at primary surgery by the ASA score, early and late postoperative complications, e.g. superficial and deep infection, peri-prosthetic fracture, prosthetic dislocation, and mortality, were extracted.

The preoperative hip status was obtained from patients by interview during the first days after surgery. The pre-fracture hip function was evaluated using the modified Harris Hip Score (HHS) and Western Ontario and McMaster Universities Arthritis (WOMAC) questionnaires (Harris 1969, Mahomed et al. 2001, Burgers et al. 2015). Cognitive function was evaluated with the Short Portable Mental Status Questionnaire (SPMSQ) (Pfeiffer 1975). When the SPMSQ score was less than 8, relatives or nursing home staff were asked to assist in completing the questionnaires. An independent research nurse performed follow-up interviews 12 months postoperatively when all patients were followed-up with PROM instruments (HHS and WOMAC). Reoperation and mortality were recorded until December 2016 or death.

Implant and surgery

A consultant orthopedic surgeon or registrar performed primary surgeries. We planned that all surgeons should gradually adopt, during a 3-year period, the use of the DL approach in displaced FNF treated with hip arthroplasty. Surgeons with experience in DL approach assisted and supervised less experienced surgeons whenever necessary. The HA was performed using the cemented SP II Lubinus system with a modular unipolar (Waldemar Link, Hamburg, Germany) or bipolar head (Waldemar Link, Hamburg, Germany) which was implanted according to the surgeon's preference either via the DL approach (Gammer 1985) or the PL approach (Moore 1957) in lateral decubitus position. In THA the acetabular components were cemented with Optipac (Biomet, Sävedalen, Sweden) and either a cemented Lubinus (Waldemar Link, Hamburg, Germany) or a cemented Avantage (Biomet, Valence, France). In both approaches, surgeons repaired the joint capsule with absorbable sutures. Antibiotic prophylaxis was given in 3 doses of 2 grams of cloxacillin at 0.5 hours before and 1.5 and 9.5 hours after the start of surgery. Clindamycin was used in patients with anaphylaxis to penicillin. Subcutaneous high molecular weight heparin was given for 10 days. Under supervision of a physiotherapist, patients were mobilized to full weight bearing on the first postoperative day. No braces were used to avoid dislocations. No restrictions were applied to patients operated using the DL approach while those operated using the PL approach were instructed to avoid flexion beyond 90 degrees, adduction, and internal rotation of the operated hip.

Statistics

Student's t-test and the Mann–Whitney U test were used for continuous normal and ordinal data respectively. All tests were 2-sided. For the PROM variables HHS and WOMAC we used a generalized linear regression model to detect the differences between the 2 groups. Cox proportional hazard unadjusted and adjusted analyses were performed in order to evaluate factors associated with reoperations and dislocation rates. We checked for the models' underlying assumptions and found them to be fulfilled. The study design and patients' follow-up ensure non-informative censoring. However, the mortality during the study period was high and might therefore have affected the results obtained and decrease the initial power. The reoperation and dislocation rates (occurring mainly during the first year after surgery) were unlikely to be affected by the differences in mortality between the 2 groups. We also checked the assumptions of proportional hazards by plotting the cumulative hazard function for each group against time (log–log cumulative hazard plot for the 2 groups) and found the lines to be parallel. A multivariable model adjusted for surgical approach, type of arthroplasty, age, sex, cognitive dysfunction, surgeon (registrar or consultant), and ASA category (1–2 or 3–4) were included in the analysis. The generalized linear model was used because neither WOMAC nor HHS was normally distributed. Gamma distribution was used due to the right shift of the curves. The selection of variables

Table 1. Study population characteristics

	PL approach (n = 146)	DL approach (n = 216)	p-value
Age, mean (range)	82 (64–99)	83 (61–99)	0.02
Sex, n (%)			
Male	44 (30)	64 (30)	1.0
Female	102 (70)	152 (70)	
Side, n (%)			
Right	63 (43)	112 (52)	0.1
Left	83 (57)	104 (48)	
Experience, n (%)			
Consultant	113 (77)	130 (60)	0.01
Resident	33 (23)	86 (40)	
Arthroplasty, n (%)			
HA	99 (68)	191 (88)	0.01
THA	37 (25)	23 (11)	
THA with dual mobility cup	10 (7)	2 (1)	
ASA, n (%)			
1–2	78 (53)	97 (45)	0.2
3–4	68 (47)	116 (54)	
SPMSQ, mean (SD)	7 (3.4)	6 (3.7)	0.4
WOMAC, mean (SD)	90.4 (11)	90.6 (12)	0.9
Harris hip score, mean (SD)	84 (13)	83 (14)	0.3
PNRS, mean (SD)	1.4 (1.4)	1.5 (1.4)	0.3

DL = direct lateral approach, PL = posterolateral approach,
HA = Hemiarthroplasty, THA = total hip arthroplasty.
SPMSQ: Short Portable Mental Status Questionnaire
WOMAC: Western Ontario and McMaster Universities Arthritis questionnaires
PNRS: Pain numeric rating scale
SPMSQ, WOMAC, Harris hip score and PNRS presented as baseline measurement.

for the analyses was an a priori hypothesis based on a literature search for known predictors of the outcome of interest. These variables were recently recommended by the International Society of Arthroplasty Registries (ISAR) PROMs Working Group (Rolfson et al. 2016). This working group recommended the inclusion of age, sex, diagnosis at joint, general health status preoperatively, and joint pain and function score in adjustment models. We also included the surgical approach since this was the variable that we aimed to study. We checked the included variables for cause–effect relations and found them to be related both to exposure and outcome, without being in the causal pathway between potential risk factor and outcome (Shrier and Platt 2008, Cook and Ranstam 2017). The associations are presented as hazard ratios (HR) with 95% confidence intervals (CI). A p-value < 0.05 was considered significant. The number of patients included in these analyses (n = 216 in the DL group and n = 146 in the PL group) would be sufficient to reveal any significant clinical and statistical differences. In each of the analyses made there were max. 7 covariates. If 10–20 patients were required for each covariate included in the analysis, then the number of patients would be sufficient.

Statistical analysis was performed using SPSS® (IBM SPSS Statistics for Macintosh, Version 22.0, IBM Corp, Armonk, NY, USA).

Table 2. Reoperations presented as number of patients (percentage)

	PL approach (n = 146) (HA = 99) (THA = 47)	DL approach (n = 216) (HA = 191) (THA = 25)	Total (n = 362) (HA = 290) (THA = 72)
Dislocation	7 (5)	3 (1.4)	10 (2.7)
HA	6 (6)	3 (1.6)	9 (3.1)
THA	1 (2)	0	1 (1)
Deep infection	9 (6)	7 (3.2)	16 (4.4)
HA	7 (7)	7 (3.7)	14 (4.8)
THA	2 (4)	0	2 (3)
Periprosthetic fracture	0	2 (0.9)	2 (0.6)
HA	0	2 (1.0)	2 (0.7)
THA	0	0	0
Other reasons	3 (2)	1 (0.5)	4 (1.1)
HA	3 (3)	1 (0.5)	4 (1.4)
THA	0	0	0
Dislocation, recurrent [a]	11 (7.5)	3 (1.4)	14 (3.9)
HA	6 (6)	3 (1.6)	9 (3.1)
THA	5 (11)	0	5 (8)

[a] Including those treated with closed reduction.
For abbreviations, see Table 1

Ethics, registration, funding, and potential conflicts of interest

The Ethics Committee of Umeå University approved the study (Dnr. 2011-428-31M, 2016-534-32). The study was registered at clinicaltrials.gov (NCT01486641). Financial support was provided through a regional agreement between Umeå University and Västernorrland County Council (ALF) and by the research and development fund granted by the County Council of Västernorrland. No competing interests declared.

Results

Study subjects and descriptive data

Between February 2012 and October 2015, 362 patients were included in the study with a median age of 82 (65–99) years of whom 254 were female (Table 1). 12 patients sustained bilateral FNF. Only the first fracture was included in the analysis. During the study period, 146 (40%) were operated with the PL and 216 with the DL approach. 290 patients (80%) were operated with an HA (Table 1).

Reoperation and dislocation rates

28 (8%) hips required re-operation at least once excluding closed reduction due to dislocation. The most common reasons for reoperations were infection (DL 3.2% vs. PL 6.2%, p = 0.2) and dislocation (DL 1.4% vs. PL 4.8%, p = 0.03) (Table 2). The rate of reoperation was lower in the DL group compared with the PL group (6% vs. 13%, HR 2.5, CI 1.2–5.2, p = 0.02). The dislocation rate was reduced from 13% in the PL to 4% in the DL group (5.4, 1.4–20, p = 0.01).

Table 3. Cox proportional hazards presenting unadjusted hazard ratios (HR) for reoperations and recurrent dislocations with 95% confidence interval (CI)

	Reoperation			Dislocation		
Variable	HR	CI	p-value	HR	CI	p-value
Surgical approach						
DL approach	1.0	–		1.0	–	
PL approach	2.2	1.1–4.4	0.03	3.2	1.5–20	0.01
Experience						
Resident	1.0	–		1.0	–	
Consultant	1.1	0.5–2.2	0.9	1.2	0.4–3.9	0.7
Cognitive dysfunction						
No	1.0	–		1.0	–	
Yes	1.5	0.7–2.9	0.3	1.8	0.6–5.2	0.3
Arthroplasty						
HA	1.0	–		1.0	–	
THA	0.5	0.2–1.5	0.2	2.1	0.7–6.4	0.2
Age	1.0	1.0–1.1	0.2	1.0	0.9–1.1	0.6
Sex						
Male	1.0	–		1.0	–	
Female	1.3	0.6–2.8	0.6	1.6	0.4–5.6	0.5
ASA						
1–2	1.0	–		1.0	–	
3–4	0.9	0.4–1.7	0.7	1.1	0.5–2.4	0.8

HA = Hemiarthroplasty, THA = total hip arthroplasty

Table 4. Cox proportional hazards presenting adjusted hazard ratios (HR) for reoperations and recurrent dislocation with 95% confidence interval (CI)

	Reoperation			Dislocation		
Variable	HR	CI	p-value	HR	CI	p-value
Surgical approach						
DL approach	1.0	–		1.0	–	
PL approach	2.5	1.2–5.2	0.02	5.4	1.4–20	0.01
Experience						
Resident	1.0	–		1.0	–	
Consultant	0.9	0.4–1.9	0.8	1.0	0.3–3.1	0.9
Cognitive dysfunction						
No	1.0	–		1.0	–	
Yes	1.4	0.7–2.9	0.4	3.4	0.9–13	0.07
Arthroplasty						
HA	1.0	–		1.0	–	
THA	0.6	0.2–2.1	0.4	3.4	0.7–17	0.1
Age	1.0	0.9–1.1	0.6	1.0	0.9–1.1	0.7
Sex						
Male	1.0	–		1.0	–	
Female	1.2	0.5–2.7	0.7	2.0	0.5–7.7	0.3
ASA						
1–2	1.0	–		1.0	–	
3–4	0.8	0.4–1.7	0.6	1.0	0.3–3.0	1.0

HA = Hemiarthroplasty, THA = total hip arthroplasty

Table 5. Patient-reported outcome variables: Generalized linear model regression including adjusted variables for Harris hip score (HHS) and WOMAC with 95% confidence interval (CI). Estimated marginal means (EM) for each covariate are included

	Reoperation				Dislocation			
Variable	EM	coefficient	CI	p-value	EM	coefficient	CI	p-value
Surgical approach								
PL approach	78.8	–	–		71.3	–	–	
DL approach	79.9	1.1	–5.7 to 7.6	0.7	72.9	1.6	–3.1 to 6.4	0.5
Experience								
Consultant	78.9	–	–		71.7	–	–	
Resident	79.8	1.1	–5.7 to 7.9	0.7	72.5	0.8	–4.2 to 5.8	0.8
Cognitive dysfunction								
Yes	74.1	–	–		69.5	–	–	
No	84.5	10.5	3.9 to 17	≤ 0.01	74.7	5.3	0.3 to 10	0.04
Arthroplasty								
THA	79.8	–	–		74.8	–	–	
HA	78.8	–0.9	–11 to 9.2	0.9	69.4	–5.3	–13 to 2.2	0.2
Age	80.8	–0.1	0.7 to 0.4	0.6	80.8	–0.08	–0.5 to 0.3	0.7
Sex								
Female	80.8	–	–		72.8	–	–	
Male	77.8	–2.9	–9.6 to 3.8	0.4	71.4	–1.3	–6.3 to 3.6	0.6
ASA								
1–2	80.5	–	–		73.7	–	–	
3–4	78.1	–2.4	–3.7 to 8.7	0.4	70.5	–3.2	–1.4 to 7.8	0.2

Cox proportional hazard analysis (both unadjusted and adjusted, Tables 3 and 4) identified the PL approach as a factor associated with an increased risk of reoperation and dislocation rates. Moreover, THA of the PL approach was associated with an increased risk of dislocations. Age, sex, ASA classification, cognitive dysfunction, or the experience of the surgeon had no statistically significant effects on the risk of reoperation or dislocation rates.

PROM

WOMAC and HHS were similar between the groups, even when adjusting for confounders. The only factor affecting HHS and WOMAC was cognitive dysfunction (Table 5).

Mortality

The mortality was high but similar in both groups. 45% in the DL groups vs. 48% in the PL group died during the study period with no difference between the groups (p = 0.8).

Discussion

The results of this prospective study demonstrate the effectiveness of the applied transition of routines in reducing the reoperation and dislocation rates while maintaining the functional outcome for FNF patients.

It is important to reduce the number of complications, such as recurrent dislocations, in FNF patients (Petersen et al. 2006, Enocson et al. 2009). Many FNF patients are frail and cannot withstand a secondary surgical procedure with the prolonged

rehabilitation. Factors reported to be associated with an increased risk for dislocation are cognitive dysfunction, male sex, advanced age, and discrepancy of offset and leg length (Mukka et al. 2015, Wallner et al. 2015, Li et al. 2016).

At the start of the gradually adopted transition period, we were concerned about the negative effect of the learning curve on the complication rate and functional outcome. All surgeons in our department were experienced in the PL approach since they had used it for all hip arthroplasty patients. We included THA with and without dual-mobility cup and HA with bi- and unipolar heads to avoid selection bias and improve generalizability of the results. This study therefore reflects the whole department's learning curve for the DL approach, which could explain the relatively higher dislocation rate for DL approach compared with other studies (Enocson et al. 2008, 2009, Sköldenberg et al. 2010, Leonardsson et al. 2012, Rogmark et al. 2014, Cebatorius et al. 2015, Parker 2015, Rogmark and Leonardsson 2016). In a review based on 23,107 cases, Varley and Parker (2004) found a dislocation rate of 2.4% after DL approach and 5.1% after PL approach. Enocson et al. (2008) published a study based on 739 patients with HA with a 3% dislocation rate after DL approach compared with 9% and 13%, respectively, after PL approach with and without posterior repair. In an identical study setting, Enocson et al. (2009) reported similar findings in patients treated with THA. Sköldenberg et al. (2010) reported a reduction in dislocation rate from 8% to 1% after changing the routine from PL to DL approach. Svenøy et al. (2017) demonstrated a dislocation rate of 8% with the PL and 1% with the DL approach in a cohort study. A recently published randomized controlled trial, comparing the 2 surgical approaches in FNF patients treated with HA with modern implants, found similar dislocation rates in the DL (2%) and PL (1%) approach and similar functional outcome (Parker 2015). Also, Keene and Parker (2013) have reported an increased risk for thrombosis with the PL approach and increased blood loss, surgical time, and postoperative infection rate with the DL approach. Biber et al. (2012) found the PL approach to be more associated with dislocation whereas the DL approach predisposed to postoperative hematoma.

We found similar infection rates and mortality between the 2 approaches. This could be due to the sample size, which might not be powered to detect such differences. Otherwise, this outcome is expected since we cannot find any obvious cause to increase the infection rate or mortality linked to the surgical approach as long as other factors such as ASA class are comparable between the 2 groups. Our infection rate (DL 3.2% and PL 6.1%, $p = 0.2$) is, however, higher than what was reported in previous studies. We have previously reported an infection rate of 4.5% after arthroplasty for FNF at our department with good results in those treated with debridement, antibiotics, and implant retention (Mellner et al. 2017). A recent Cochrane review reported 2.8% superficial infections and 2.5% deep infections after HA for FNF (Parker et al. 2016). In studies with FNF patients, there is a tendency to exclude patients with cognitive dysfunction and this may contribute to a lower incidence of complications (Mundi et al. 2014). Register-based studies tend also to underestimate the number of complications, mainly those not treated with reoperations (Lindgren et al. 2014, Gjertsen et al. 2014). In our study, we found a low rate of peri-prosthetic fractures, probably due to our use of a cemented anatomic stem (Mukka et al. 2016).

Until recently there have been few studies comparing the influence of different surgical approaches on PROM and quality of life (Parker 2015, Leonardsson et al. 2016, Kristensen et al. 2017). In an observational study by Leonardsson et al. (2016) the surgical approach for hemiarthroplasty did not influence PROM. In contrast to this, a registry study from the Norwegian Hip Fracture Register presented favorable results for the PL approach in the fracture population (Kristensen et al. 2017). However, this study included a skewed distribution of patients between the different approaches (DL 18,918 vs. PL 1,990) and marked differences in the distribution of cemented and uncemented fixation (DL 25% cemented vs. PL 57% cemented). In a recently published randomized controlled trial by Parker (2015), 216 patients were treated with HA and randomized between DL and PL approaches without stratifying for differences in residual pain or regain of walking ability. However, the author either performed or supervised all procedures and patients that were operated on by others were excluded. This could have introduced a performance bias that may limit the generalizability of the results. The DL approach might also increase the risk for gait disturbances and trochanteric tenderness (Sayed-Noor et al. 2016). However, in the elderly population with FNF, the impact of the potential functional impairment is less pronounced compared with younger patients.

We found no effect of age, sex, ASA classification, type of arthroplasty, cognitive dysfunction, or the experience of the surgeon on the reoperation and dislocation rates. Also, we found no statistically significant difference in PROM between the 2 approaches. These findings could be associated with certain estimation uncertainty caused by the relatively limited number of patients included in the analysis. Larger studies such as register-based or multicenter cohorts could show some effects of 1 or more of the above variables or differences in PROM between the 2 approaches.

Our study has a number of limitations. The follow-up time is relatively short. However, the first postoperative year's outcome is the most important in this population due to their high mortality. Moreover, surgical complications in this group are mainly encountered early. The study design could impose both information and selection biases when surgeons choose the approach they prefer. Also, we have to consider the risk of confounding by indication according to the surgical technique. The difference in the selection of type of arthroplasty between the approaches could possibly have contributed to the higher dislocation rate in the PL group. However, dual mobility cups

are associated with lower dislocation rate (Bensen et al. 2014) and could neutralize the increasing rate in the PL group caused by the high number of THA patients. The limitations are counterbalanced by the strengths of the study, which is a prospective cohort study with consecutive patients, minimal dropout, and good generalizability.

In summary, in patients with FNF, it is possible to reduce the reoperation and dislocation rates by changing the surgical approach used for hip arthroplasty without affecting PROM.

SM: study design, data collection, statistical analysis, data analysis, manuscript writing. BK: data collection and analysis.AM: statistical analysis. ASN: study design, data analysis, manuscript writing, study supervision.

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