Should advanced age be a contraindication to total hip arthroplasty in femoral neck fracture patients? A matched-control, retrospective study

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ABSTRACT

Introduction: Due to demographic changes, the annual incidence of femoral neck fractures (FNF) in patients reaching the 9th and 10th decade of life is increasing. Although active and cognitively intact elderly patients could benefit from total hip arthroplasty (THA) in case of a FNF, there is no clear consensus on whether THA should be performed in this particular subgroup of patients with very advanced age. The purpose of this study was to report the complication rate, mortality, clinical outcomes and quality-adjusted life year (QALY) gained in patients treated with total THA for FNF, while having exceeded the mean life expectancy at the time of surgery, compared to a younger control group.

Materials and Methods: Patients treated with THA through a direct anterior approach (DAA) for FNF and exceeding the average life expectancy in Switzerland (age ≥ 83 y, $n = 45$) were matched for gender, body mass index (BMI) and ASA score with patients under the age of 83 (age = 65–83, $n = 45$). Perioperative complications, clinical and radiologic outcomes, as well as mortality were compared between groups.

Results: Total complication rate did not differ significantly with 22.2% in the older group compared to 17.8% in the control group. The 30-day and 1-year mortality was slightly but not significantly higher in the older group (2.2% and 8.9% vs. 2.2% and 2.2%). The average QALY gained was 3.4 years and 4.1 years for the older group and their younger counterparts, respectively.

Conclusion: THA through the DAA for FNF in cognitively intact and active patients might be a credible and safe option even after reaching mean life expectancy with excellent functional outcomes and similar surgery-related complications compared to patients younger than 83 years. Our results imply that an advanced age should not be considered a contraindication for THA in case of a FNF.

1. Introduction

Femoral neck fracture (FNF) is the most common osteoporotic fracture in elderly patients.¹ Due to demographic changes and the soaring proportion of older patients, the annual incidence of FNF in patients older than 85 years is increasing more than in every other age group.¹ Furthermore, it is expected that the numbers will grow in the forthcoming decades.² Total hip arthroplasty (THA) is one of the most successful, cost-effective, and efficient interventions in medicine.^{3–5} However, the optimal surgical treatment of the elderly patient with a displaced FNF remains controversial.⁶ Most geriatric patients with FNF are treated with hemiarthroplasty (HA) because this procedure is associated with shorter surgical duration, lower blood loss as well as lower dislocation rates⁷ compared to THA, and therefore provides a satisfying solution particularly in very low demand individuals.

However, recent reports show lower reoperation and mortality rates in patients around the 80th life year when treated with THA compared to HA,⁸ as well as a significantly lower pain scores.^{9,10}

Furthermore, there is evidence suggesting that particularly active, cognitively intact elderly, who live independently, could benefit from better long-term outcome inherent to THA.^{1,8} Additionally, a high activity level and the length of follow-up are the most important factors leading to acetabular erosion and revision arthroplasty in hemiarthroplasty patients.¹¹

Choosing the appropriate surgical treatment tailored to patient's profile represents a daily struggle in a trauma or orthopaedic surgeon's life. In active, cognitively intact and otherwise healthy geriatric FNF patients, age and pre-existing osteoarthritis are the determining factors whether THA or HA should be performed. To this date, no clear consensus with regard to the age as a contraindication to THA, exists.

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Therefore, the purpose of the current study was to compare mortality, complication rate and functional outcome after THA because of a displaced FNF between patients who have already exceeded the average life expectancy (in Switzerland: 83 years) and a matched-controlled group of patients under the age of 83.

2. Materials and Methods

Our institution's Internal Review Board and the ethical committee approved the study (Project ID (EKNZ) 2016-01837). It was conducted entirely at the authors' institution.

In our institution, we perform all elective and emergency THA and HA through the DAA. Patients with a FNF received a THA irrespectively of their age if they were cognitively intact and disclosed an active and independent lifestyle. In the trauma setting, our selection criteria depend on the ability to perform the grocery shopping unassisted and not living in a residential long-term care facility. In case these criteria were not met, a HA was performed instead. Patients with an advanced stage of cancer or known neurological disorders also received a HA.

2.1. Patient characteristics

Between January 2011 and August 2016, 45 THA were performed for displaced FNF in 44 patients who exceeded Switzerland's mean life expectancy of 83 years. These patients were matched for sex, BMI, and ASA Score with 45 patients aged less than 83 years (Table 1), who were treated with THA for displaced FNF. In all of these cases, osteosynthesis was no valuable alternative.

All patients were operated on within 48 h from admission to the emergency room.¹² Best possible conditions for the patient were pursued during this time, for instance repeating therapeutic anticoagulation and optimizing blood glucose level.

2.2. Surgical technique and postoperative care

All cases were performed via a standardized minimally invasive DAA in a supine position using the AMIS Mobile Leg Positioner (Medacta International SA, Castel San Pietro, Switzerland). Every patient received preoperative antibiotics before skin incision and for 24 h postoperatively. The proximal femur neck was resected at the appropriate level according to preoperative planning, protecting the surrounding tissues with retractors. During the insertion of the acetabular component, intraoperative imaging was used. The anterior hip capsule was left open for all the procedures. The components implanted were either a Versafit cup in combination with a cemented AMISem or a

Quadra stem (Medacta, Castel San Pietro, Switzerland).

Our postoperative pain management featured an intracapsular pain catheter with bupivacaine 0.5% (49.25 mL), epinephrine 0.5 mg (0.5 mL) with or without ketorolac 30 mg (1 mL) according to patient's kidney function, inserted during operation, and oral analgesia. Patients were mobilized as soon as possible following a standardized physical therapy protocol consisting of mobilization out of bed and progressing from a walker to no assistive devices as tolerated. A bladder catheter was not used routinely but when needed due to postoperative urinary retention. Non-pharmacological delirium prophylaxis was performed and oral antipsychotics administered as needed. After mobilization, anteroposterior and axial X-ray was performed. The length of stay depended on wound healing, pain, and mobility and the availability of a rehabilitation facility. As deep venous thrombosis prophylaxis, Rivaroxaban 10 mg once daily for 30 days was prescribed if patients had no pre-existing antithrombotic medication.

2.3. Clinical evaluation

In our institution, patients are followed up clinically and radiologically after 3 months, as well as one and five years after surgery. Operative records were analyzed, the American Society of Anesthesiologists (ASA) classification, intraoperative blood loss, surgical duration, type of anesthesia, and hospitalization time, as well as intraoperative, perioperative and postoperative complications, and discharge disposition were assessed. Complications were defined as undesired or unexpected results of the operation, including but not limited to dislocation, infection, and death during hospitalization.

At every visit, Harris hip score (HHS) was recorded and EuroQol-5D (EQ-5D) was assessed. The quality-adjusted-life-year (QALY) is a well-established indicator of the quality-of-life of the remaining years¹³ and was calculated as the years of life following the operation, multiplied by the utility value, for the current study, defined as the postoperative EQ-5D at 1-year follow-up. Each question in the EQ-5D score (total 5) received 0 (minimum) to 0.2 (maximum) points. The minimum and maximum EQ-5D score were therefore 0 and 1, respectively. A QALY score of 1 indicated one year of excellent health. The clinical examination was performed by an orthopaedic surgeon of our department not involved in the study in a standardized matter. Medical records were reviewed, including outpatient clinic notes, operative reports, and hospital records for readmission. For a final follow-up, all patients were additionally interviewed by telephone.

2.4. Radiologic measurements

The postoperative x-rays were evaluated by 2 separate orthopaedic residents blinded to patient's clinical details. The residents performed the measurements individually and concurred with the results. Radiographs of each visit were compared with the initial postoperative radiograph to evaluate for component loosening.

For the pre- and postoperative radiographs, a standardized protocol has been applied with the patient in a supine position, the lower limbs held together in slight internal rotation, and the anterior superior iliac spine parallel to each other and the x-ray table. Acetabular inclination and leg-length discrepancy (LLD) were measured in the anteroposterior view. LLD was defined as the perpendicular distance between a line passing through both pelvic teardrops to the corresponding tip of the lesser trochanter.¹⁴ In the lateral view, anteversion was quantified according to the technique reported by Woo and Morrey.¹⁵

2.5. Statistical analysis

Descriptive statistics used frequencies and percentages to present the data. All parameters were tested for normality. When the criteria for normality were met, a 2-tailed *t*-test was used. Otherwise, the Wilcoxon signed-rank test was applied. The relative risk was calculated to identify

Table 1

Patient characteristics, follow-up and postoperative functional score. ASA (American Society of Anesthesiologists). BMI (body mass index). The values were given in mean value and standard deviation or percentage. * Indicates statistically significant difference ($P < 0.05$).

	Age > 83 (n = 45)	Age < 83 (n = 45)	Significance (P-value)
BMI (kg/m ²)	24.2 (3.35)	24.5 (3.7)	0.33
Age (Years)	88 (3.1)	79 (3)	< 0.05*
Gender			
Male (n)	11 (24.4%)	10 (22.2%)	
Female (n)	34 (75.6%)	35 (77.8%)	
ASA-score	2.4 (0.6)	2.5 (0.5)	> 0.05
1 (n)	0	0	
2 (n)	28 (62.2%)	27 (60%)	
3 (n)	14 (31.1%)	18 (40%)	
4 (n)	3 (6.7%)	0	
Postoperative Harris Hip Score at 1-year	90.4 (8.8)	94.4 (6.7)	0.26
Follow-up (months)	32.3 (23)	36.1 (21)	

if patients older than 83 years had an increased risk of postoperative complications compared to their younger opposites. A Kaplan-Meier curve was generated to analyze patient survivorship following the surgery. For the acetabular inclination and anteversion, intraobserver and interobserver reliabilities of the measurements were evaluated with 2 independent blinded observers using single-measure intraclass correlation coefficients (ICC) with a 2-way random-effects model for absolute agreement. The level of significance level was set at $\alpha = 0.05$. All the statistical analyses were performed using SPSS version 23 software (SPSS Inc., Chicago, Illinois).

3. Results

3.1. Power analysis and intraobserver and interobserver reliabilities

The achieved power of the study according to the post hoc power analysis with a total sample size of 90 hips, medium effect size, and $\alpha = 0.05$ was 90%. Intraobserver ICC and interobserver ICC were 0.94, 0.9 for anteversion and 0.98, 0.98 for inclination, respectively.

3.2. Patient characteristics

A total of 45 THAs in 44 FNF patients (male: 11, female: 34), with an average age of 88 years (range 83–96), were identified (group A) (Table 1). The average follow-up period was 32 months (range 12–72 months, all deceases within 12 months excluded). The control group (group B) consisted of 45 patients with an average age of 79 years (range 71–82 years) and an average follow-up of 36 months (range 12–70 months). Both groups were matched for ASA score, gender and BMI (Table 1).

3.3. Perioperative parameters

The duration of surgery was similar in both groups (96.2 vs. 98.6 min; ranges 50–152 in Group A and 50–159 in Group B). Intraoperative blood loss was 100 ml less in group A, which was not statistically significant. 23% of the patients in group A and 9% of the patients in group B were monitored in the postanesthesia care unit (PACU), mostly due to preexisting medical comorbidities. Hospital stay was 2.8 days longer (10.2 vs. 7.4 days, $p = 0.054$) in the group A (Table 2).

3.4. Complication rate and revision

At an average follow-up of 32 months, the total complication and reoperation rates in patients in group A were 22.2% and 11.1%, respectively (Table 3). One hip dislocation occurred (2.2%) and was treated with a closed reduction in the emergency department without

further dislocations. Wound dehiscence occurred in one patient (2.2%) requiring local wound debridement. Two patients needed revision because of a hematoma. Medical-related complications consisted of a pulmonary embolism after femoral cementing (1 patient), postoperative delirium (2 patients) and one in-hospital death due to heart failure (2.2%).

The total complication and reoperation rate in group B was 17.8% and 8.9%, respectively (Table 3). No dislocation occurred. One patient was treated with local wound debridement because of a wound dehiscence and one patient needed revision because of a hematoma. One intraoperative periprosthetic fracture was treated with additional cerclages. Three medical-related complications occurred (6.7%): 1 patient developed a cardiac arrhythmia, one patient had a postoperative delirium, and one in-hospital death occurred because of heart failure.

The incidence of postoperative periprosthetic fractures was similar in both groups ($n = 2$). Although the rate of medical-related complications, total complications and reoperations was slightly higher in group A, it was not statistically significant (RR 1.33, $p = 0.69$; RR 1.25, $p = 0.6$; RR 1.25, $p = 0.72$, respectively) (Table 3).

3.5. Mortality

The 30-day mortality was 2.2% for both groups. The 1-year mortality was 8.9% for group A compared to an unaltered 2.2% for group B. The Kaplan-Meier curve showed a survival rate of 80.4% in group A and 86.9% in group B, at 60 months following the operation (Fig. 1). The hazard ratio of death was 4.1 ($p = 0.05$) in patients who surpassed the average life expectancy compared to their younger counterparts.

3.6. Functional outcomes and QALY

The average HHS, one year following THA, was 90 and 94 points, in group A and B, respectively ($p = 0.26$). The average QALY was 3.4 years (range 0–5 years; standard deviation 2.9) for patients who exceeded life expectancy and 4.2 years (range 0–5 years; SD 2.5) for their younger counterparts ($p = 0.1$).

3.7. Radiographic findings

The average acetabular inclination and anteversion were similar in both groups (40.6° and 20.1° for the elderly cohort compared to 40.4° and 21° in the control group, respectively). No difference in leg-length was observed between the groups ($p = 0.5$).

4. Discussion

Globally, HA seems to be the preferred treatment method for patients in a very advanced age.¹⁶ However, current evidence indicates THA to be the superior treatment option for active patients with a longer life expectancy^{17,18} due to the unfavorable outcomes^{19–21} linked to HA, especially concerning pain level^{9,10} and acetabular erosion.¹¹ Nevertheless, THA is a more invasive operation and harbours higher risks in patients with advanced age and thereby limited physiological reserves.^{22,23} Optimal treatment of FNF in the elderly population is still a focus of vigorous debate. Especially, it is unclear whether age should be considered a contraindication for THA in FNF, even if the patient is otherwise healthy and would formally qualify for a THA. The purpose of this study was therefore to report a cohort of patients who have exceeded the mean life expectancy but underwent THA for FNF due to their independent and active lifestyle. We hypothesized that active, cognitively intact and independent living geriatric patients could, irrespective of their advanced age, benefit from long-term advantages of THA with no statistically significant increase of medical- and surgery-related risks. For this purpose, we compared complication and revision rates, clinical outcomes, and mortality to a control group with an average age of 79 years. The 30-day mortality was the same between

Table 2

Perioperative parameters. The values were given in mean value and standard deviation or percentage. PACU: post-anesthesia care unit.

	Age > 83 (n = 45)	Age < 83 (n = 45)	Significance (P-value)
Intraoperative blood loss (ml)	305 (200)	401 (320)	0.06
Operation duration (min)	96.2 (28)	98.6 (32.8)	0.67
Hospital stay (days)	10.2 (7)	7.4 (5.2)	0.054
PACU postoperative (n)	10 (22%)	4 (9%)	< 0.05*
In-hospital deaths (n)	1 (2.2%)	1 (2.2%)	1
Death after hospital stay (n)	8 (17.8%)	1 (2.2%)	0.0001*
Place of discharge			
Rehabilitation (n)	27 (60%)	23 (51%)	
Retirement home (n)	12 (26.7%)	5 (11%)	
Home (n)	5 (11.1%)	17 (38%)	

Table 3

Summary of complications. RR: Relative risk. All periprosthetic fractures occurred postoperatively because of a new traumatic incident. * Indicates statistically significant difference ($P < 0.05$).

	Age > 83 (n = 45)	Age < 83 (n = 45)	Relative Risk (RR)	Significance (P-value)
Deep infections (n)	0	0	1	1
Wound dehiscence (n)	1 (2.2%)	1 (2.2%)	1	1
Dislocation (n)	1 (2.2%)	0	3	0.5
Intraoperative periprosthetic fracture (n)	0	1 (2.2%)	0.33	0.5
Postoperative periprosthetic fracture (n)	2 (4.4%)	2 (4.4%)	1	1
Hematoma needing revision (n)	2 (4.4%)	1 (2.2%)	2	0.56
Reoperation (n)	5 (11.1%)	4 (8.9%)	1.25	0.72
Medical-related complication (n)	4 (8.9%)	3 (6.7%)	1.33	0.69
Total complications (n)	10 (22.2%)	8 (17.8%)	1.25	0.6

Fig. 1. Kaplan-Meier curve shows the survival rate following total hip arthroplasty in patients with mean age of 88 years (continuous blue line) and patients with mean age 79 years (red interrupted line).

the groups, and 1-year survival was in favor of younger patients with 97.8%–91.1%. Although the rate of medical-related complications, reoperations, and total complications was higher in the older group it was not statistically significant compared to the control group. A mean QALY of 3.4 years was achieved even though life expectancy was surpassed at time of operation whereas in the control group mean QALY was 4.2 years.

The primary concern of THA following FNF in elderly patients is the increased complication risk and mortality caused by the limited physiological reserves and the associated comorbidities.^{24,25} Regarding mortality, Maceroli et al.⁸ reported a 1-year mortality of 25.9% for HA (mean age 82.5 years) compared to 17% for THA (mean age 79.1 years). A lower 1-year mortality following HA was reported by Lim et al.²⁶: Divided into groups by age, the mortality rate was 12.6% and 21.7% for patients aged 85–89 years or older than 90 years, respectively. Other studies reported similar results.²⁷ Kammerlander et al.,²⁸ while focusing on a population with hip fractures older than 85 years (mean age 86.8 years), found an in-hospital mortality of 2.8% and a 1-year mortality of 23.2%. Of all FNF reported, only 1% was treated with THA. In the current study, we performed THA in case of FNF depending on patients' cognitive and physical function and regardless of their age. We reported a considerably lower 1-year mortality compared to the literature despite the higher age of our patients. However, this value has to be put into perspective due to our deliberately generated selection bias, as we implanted THA instead of HA only in patients with a good mental status in combination with an active lifestyle. Nevertheless, compared to a control group averagely aged 79 years, the 30-day rate and 1-year mortality rate still did not significantly differ. However, as expected, the survival rates vary afterward with a 5-year survival of 80.4% for patients older than 83 years and 86.4% for the control group. These findings match official data from the Swiss Federal Office for statistics,²⁹ where at an age of 80 and 90 years, an average

life expectancy of still 9.55 and 4.25 years, respectively, is reported. Our results therefore imply that age alone might not be necessarily a contraindication to THA. However, particular attention to patient selection might be necessary. Our data suggest that certain geriatric patients might indeed benefit from the long-term advantages of THA despite their advanced age.

Dislocation is the major concern after primary total hip arthroplasty for the treatment of a FNF. The surgical technique used for THA after FNF undoubtedly affects the complication profile.³⁰ In this matter, Baker et al.³¹ showed a dislocation rate of 7.5% (3 of 40 patients) after THA for a FNF through the anterolateral approach. Other authors, not using minimal-invasive approaches, report dislocation rates up to 20% for FNF patients after THA.^{19,20} Thürig et al.³² investigated the safety of THA after FNF in 86 elderly patients through the DAA. Along with other investigators using a minimally invasive approach for FNF, a low dislocation rate is reported and mainly attributed to the soft-tissue preserving nature of the DAA.^{33,34} Data in literature is limited, as the DAA approach is not widely used in the trauma setting. We report a low dislocation rate in our study with only one dislocation (2.2%) in the group of elderly patients averagely aged 88 years. Regarding the total complication rate, only few studies reported a detailed summary of complications after THA in case of FNF. Lioudakis et al.³⁵ reported a total complication rate of 15.7% in a cohort of 866 patients averagely aged 72.7 years, which is similar to our results. Compared to patients with mean age of 86 years (n = 100), who received an elective THA at our institution,³³ FNF patients in this study had a slightly higher hip-related complication rate (8.8% - when excluding postoperative periprosthetic fractures - vs. 6%) and medical-related complications (8.9% vs. 6%). In that elective cohort³³ 1-year mortality was 6%. Therefore, our data goes in accordance with the results of Kieffer et al.,²⁷ who concluded that performing THA in selected geriatric patients does not hold a high risk for complications.

Patients who have already exceeded the average life expectancy could significantly benefit from an emergency THA instead of HA regarding pain relief, function, and improvement of their quality of life. A significantly lower pain rate in patients treated with THA instead of HA was previously reported.^{9,10} In the study of Lee et al.,¹⁹ 69% of the patients treated with THA due to FNF reported that they regained or improved their level of function compared to their preoperative status. Pagnano et al.³⁶ for example showed that total knee arthroplasty is a safe and effective procedure in patients (n = 51) 90 years or older and it results in years of marked pain relief for those patients. In our study, the average QALY was 3.4 years, meaning that patients who exceeded the average life expectancy gained on average 3.4 years of excellent health. Average QALY, as well as average HHS, did not significantly differ between the elderly patients and their younger counterparts.

This study should be interpreted in light of its potential limitations, mostly inherent to the retrospective design and the small number of patients. However, it is the first study to provide a patient cohort with such an advanced age and compare it to a younger matched control group. Furthermore, due to the standardized clinical and radiological

follow-up protocol and the excellent documentation by the orthopedic surgeons of our institution, most of the patient data needed was available for the current analysis. Finally, this study was performed in Switzerland, which is characterized by one of the highest life expectancies in the world meaning reported values should be translated to the average life expectancy of each country, and not the average age of 83 years.

In conclusion, this data might suggest that age alone should not be a contraindication to THA in FNF patients. Active and independent elderly patients could potentially benefit from an improved functional outcome linked to THA with a moderately increased perioperative risk, as well as 30-day and 1-year mortality, even after having exceeded average life expectancy. Nevertheless, careful patient selection might be necessary to minimize the risk of preoperative complications. Lastly, the DAA might have potential benefits over other approaches in elderly patients particularly in regard to recovery time and dislocation risk.

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Conflicts of interest

The authors declare that they have no conflict of interest regarding this study. PD Dr. Naeder Helmy is a medical advisor of Medacta International (Switzerland) and receives royalties from Medacta International (Switzerland). Dr. Helmy reports no conflict of interest in relation to this article.

Declarations of interest

None.

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