Geriatric Orthopaedic Surgery & Rehabilitation
Volume 12: 1–7

DOI: 10.1177/21514593211050153
journals.sagepub.com/home/gos
SAGE

Early Results in Non-Displaced Femoral Neck Fractures Using the Femoral Neck System

Raffael Cintean, MD[1], Carlos Pankratz, MD[1], Matti Hofmann, MD[1], Florian Gebhard, PhD[1], and Konrad Schütze, MD[1]

Abstract

Introduction: Femoral neck fractures in the elderly are a major event and are rising in incidence over the last decade. Advancing age and numerous comorbidities largely account for high mortality rate and require geriatric expertise. Treatment options are total hip arthroplasty (THA), hemiarthroplasty (HA) or osteosynthesis. Literature suggests THA or HA for better outcomes, although no clear guidelines exist. **Material and methods:** A retrospective chart review was performed of 63 patients (80 ± 11 years; 32 women, 31 men) with Garden one femoral neck fractures treated between June 2018 and June 2020 with either HA or internal fixation with the Femoral Neck System (FNS). Primary outcome measures were surgical and non-surgical complication rates and best achievable mobilization during the hospital stay. **Results:** Thirty four patients were treated with HA, and 29 with the FNS. Mobilization was measured using the Charité Mobility Index (CHARMI). No difference between age, ASA, CCI or preoperative CHARMI was found. The CHARMI was significantly lower in the HA group. No difference in surgical complications was found. The HA cohort showed more non-surgical complications, a longer ICU stay and more blood transfusions. Hospitalization was significant longer in the HA than the FNS cohort (15.1 ± 5.1 vs 9.8 ± 3.8 days). Radiographic controls were performed after 6 and 12 weeks. The FNS group showed a mean shortening of 3.3 mm. 4 of 21 patient had shortening >5 mm. 20 of 21 patients showed radiographic signs of bone healing after 3 months. **Conclusion:** Early results with the FNS show faster recovery than patient with hemiarthroplasty. Internal fixation with the FNS may be an option in non-displaced femoral neck fractures. Further studies should be performed to better evaluate the FNS compared to traditional internal fixation methods and arthroplasty.

Keywords

Femoral Neck System, hemiarthroplasty, total hip arthroplasty, geriatric, comorbidities

Introduction

Demographic changes show a rising number of the elderly population. With this trend, the fragility fractures in geriatric patients increase. Hip fractures in particular are predicted to increase substantially over the next decades.[1] Additionally, these patients often are treated for chronic comorbidities which increase the perioperative risk for severe complications.[2-5] Especially in elderly patients, hip fractures are reported having a high mortality rate between

[1]Department of Trauma-, Hand-, and Reconstructive Surgery, Ulm University, Ulm, Germany

Submitted June 5, 2021. Accepted September 13, 2021

Corresponding Author:
Raffael Cintean, Department of Trauma-, Hand-, and Reconstructive Surgery, Ulm University, Albert-Einstein-Allee 23, Ulm 89070, Germany.
Email: raffael.cintean@gmail.com

6 and 11% within the first 30 days after trauma.[6-8] The decision for the best possible treatment of hip fractures in elderly patients remains a challenge for the attending othopedic surgeon. Studies reported a higher mortality rate and lower functional outcome in patients with chronic comorbidities.[5,9,10] The treatment options for hip fractures include total hip arthroplasty (THA), hemiarthroplasty (HA), closed reduction and internal fixation (CRIF) and non-operative treatment. The decision for the type of treatment is made by the attending surgeon and is based on several factors like biological age, comorbidities, fracture pattern and pre-existing arthrosis. Non-operative treatment was reported to have an increased 30-day and 1-year mortality as well as higher complication rate compared to operative treatment. In the last years, the gold standard for hip fractures in elderly patients with comorbodities was hemiarthroplasty.[10,11] Several studies reported a better clinical outcome for elderly patients especially with displaced femoral neck fractures treated with hemiarthroplasty compared to CRIF.[12-15] A recent study however showed poor clinical outcome of elderly patients with hip fractures and comorbidities treated with hemiarthroplasty.[2] Since June 2018, we use the Femoral Neck System (FNS, DePuy-Synthes, Zuchwil, Switzerland) for minimal invasive hip fractures classified Garden I. The FNS provides the possibility of minimal-invasive, joint preserving internal fixation (IF) and showed a valid alternative treatment for other osteosynthesis techniques like sliding hip screw or cannulated screws.[16-18] In this study, we wanted to compare the outcome of elderly patients with multiple comorbidities with undisplaced femoral neck fractures treated with a hemiarthroplasty or the new Femoral Neck System.

Methods

The study was a retrospective exploratory review at a Department of Trauma Surgery, Hand Surgery, Plastic Surgery and Reconstructive Surgery at a Level One Trauma Center. Between June 2018 and June 2020, patients with femoral neck fractures classified Garden I were identified using the ICD-Code (International Statistical Classification of Diseases and Related Health Problems) as well as the OPS Code, which is the German equivalent to the International Classification of Procedures in Medicine (ICPM). For the HA group, we included every patient admitted to our hospital with a femoral neck fracture classified Garden I with the ASA score 3 and higher which was treated with a HA. For the FNS group, we included every patient admitted to our hospital with a femoral neck fracture classified Garden I with the ASA score 3 and higher treated with the FNS system. Patients with ASA scores lower than 3 and patients not treated either with HA or the Femoral Neck System were excluded. In the HA cohort, every patient received the same combination of implants with Corail AMT stem and a self-centring bipolar head (DePuy-Synthes). The decision to use a cemented stem was made individually by the attending surgeon for each case. The FNS cohort received the new FNS with a one-hole plate. Postoperative care was standardized with early mobilization using special sitting, standing and walking aids under supervision of a physiotherapist.

In this study, clinical records including patient charts, anaesthesia protocols, surgery reports and pre- and postoperative X-rays were reviewed. The patient charts were reviewed for diagnosed comorbidities and ASA classification, time-to-surgery as well as pre- and postoperative mobility (Table 1). The comorbidities were then classified and ranked with the Charlson comorbidity index (CCI). The mobility was classified with the Charité Mobility Index (CHARMI, Table 2) measured and recorded by the physiotherapists every day. The best CHARMI achieved during hospitalization was used in this study. Additionally, the postoperative complications were reviewed and put in groups of surgical complications (dislocation, periprosthetic fractures, cut-out of the FNS, local infection and haematoma) and non-surgical complications (urinary tract infection, pneumonia, acute kidney failure, heart attack and anaemia). The length of stay on the intensive care unit (ICU), the total length of stay in the hospital and the continuitiy of care after discharge were also reviewed.

Data analysis was performed with IBM SPSS Statistics (V12.0) and Microsoft Excel (V15.2). Demographic characteristics are described as mean and standard deviation. For the primary outcome measures, logistic regression was performed considering all variables related to the postoperative mobility. For the secondary outcome measures, logistic regression was also performed considering all variables related to surgical and non-surgical complications and hospital mortality.

The study was approved by the institutional ethical committee.

Results

Hospital Stay

All patients were treated in an orthopaedic trauma ward with orthogeriatric care. Time to surgery in HA cohort was an average of 23.2 vs 14.3 h in the FNS group. The cohorts showed a significant difference ($P < .001$) in postoperative intensive care treatment. The HA cohort spent an average of 2.1 ± 3.7 days on the ICU. The FNS group showed an average length of stay of .2 ± 1.1 days. The overall length of stay in the hospital also showed a significant difference ($P < .001$) with an average of 15.1 ± 5.1 days in the HA group vs 9.8 ± 3.8 days in FNS group.

Table 1. Patients' Demographics.

Variable	Total	HA	FNS	*P*-Value
Patients	63	34	29	
Mean age (years)	80 (63–99)	80.35	79.57	.767*
Male (%)	31	17 (54.8%)	14 (45.2%)	
Female (%)	32	17 (53.2%)	15 (46.8%)	
Mean ASA score	3.4 ± 0.5	3.5 ± 0.5	3.4 ± 0.5	.466†
Mean CCI (SD)	6.9 ± 1.9	7.2 ± 1.9	6.7 ± 1.8	.252‡
Dementia (%)	32 (50.8%)	18 (52.9%)	14 (48.3%)	.547*
Haemodiluting drugs[1] (%)	45 (71.4%)	26 (76.5%)	19 (65.5%)	.518*

*t-test, †Chi-square test, ‡Mann–Whitney test.
[1]Including all DOAC and Warfarin.

Table 2. CHARMI Short Manual. (1. Count the Best Mobility Item That can be Performed Without Assistance. 2. Aids May be Used. 3. Count the Wheelchair Mobility Seperately (e.g. 4+W)).[19]

Score	Mobility	
0	Complete immobility	
1	Transfer in bed	Turning from back to side
2	Sitting on edge of bed	Sit ≥30 s, transfer may need assistance
3	Transfer to edge of bed	Transfer into sitting position
4	Transfer from bed to chair	
5	Standing up	With standing for ≥30 s
6	Walking up to 10m	e.g. within a room
7	Walking 10–50 m	e.g. within a ward or inside the home
8	Walking over 50 m	e.g. outside a ward or the home
9	Climbing stairs	≥1 flight of stairs
10	Full mobility	≥1 km
+W	Wheelchair mobility	

Postoperative Mobility

To measure the mobility, the difference of the CHARMI score pre- and postoperative was used. In the HA group, the average preoperative CHARMI score was 7.1 ± 1.3 with no bedridden patient. In the FNS group the average preoperative score was 7.9 ± 2.2 with two patients where only a transfer in bed was possible. The postoperative deterioration of the CHARMI score showed a significant difference between the two cohorts. In the HA group a deterioration of the score was an average of −2.9 ± 1.7 whereas the FNS group showed a deterioration of −1.0 ± .9.

Complications

Eight out of 63 (12.7%) patients suffered from surgical complications in total.

In the HA cohort, three patients showed a postoperative seroma from which two needed revision surgery. One patient suffered from multiple dislocations of the bipolar head prosthesis and needed convertion into total hip arthroplasty after 3 months.

The FNS group showed no postoperative surgical complications during stay. A cut-out of the Femoral Neck System has occured in four patients. (13.8%) Three patients needed a conversion into a HA after an average of 26 days (14–58 days). One patient with a minor cut-out was bedridden and only an implant removal was performed for pain management after 18 months. No significant difference in surgical complications was found between the two cohorts.

A significant difference in non-surgical complications between the two cohorts was found ($P < .05$). 23 out of 34 (64.7%) patients suffered from one or more non-surgical complication in the HA cohort such as urinary tract infection (20.6%), anaemia (14.7%), pneumonia (8.8%) or cardial decompensation (5.9%). Three patients suffered from a heart attack of which two needed cardiopulmonary resuscitation. All three patients in the cohort died during hospitalization. (8.8%) Further non-surgical complications found were first degree decubitus, hyponatremia and acute pancreatitis with one occurence each (2.9%). The mortality rate after 3 months was 14.7%.

In the FNS cohort, a total of 11 non-surgical complications (37.9%) were found. Four patients suffered from uricany tract infection (20.7%) and two from arrhythmias (6.9%). Further complications like hyponatraemia, hypokalaemia, urolithiasis and anaemia were found once each (3.5%). Two patients of the FNS cohort died during hospitalization due to cardiopulmonary complications (6.9%).

A significant difference ($P < .001$) in necessity of postoperative blood transfusions could be found. The HA cohort needed an average of 2.1 packed red blood cells (PRBC) vs an average of .2 PRBC in the FNS cohort (Table 3).

Follow-Up

Mean follow-up HA cohort was 12.5 (0–22) months, in the FNS group 3.9 (0–18) months.

In the HA cohort, 31 patients got radiographic controls after 6 weeks and 26 after 3 and 12 months. Three patients (8.8%) showed periprosthetic fractures after HA after 4, 7 and 11 months unrelated to the initial treatment and needed surgery. No further case of surgical-related complication was found.

On 21 of the 29 patients with the FNS, we performed radiographs after 6 weeks and 3 months. Three patients needed conversion into HA due to cut-out, two died during hospital stay and three were lost during follow-up. All 21 patients showed shortening of the femoral neck. Mean shortening was 3.3 ± 4.5 mm (2–9 mm). Four of these patients (19%) showed shortening of > 5 mm in the radiographic control after 3 months. In the limited time of follow-up, no case of avascular necrosis of the femoral head was found. Except one patient with minor cut-out, 20 (95.2%) patients showed radiographic signs of bone healing after 3 months.

Discussion

In this study, internal fixation with the Femoral Neck System showed promising early results in non-displaced femoral neck fractures in geriatric patients with severe comorbidities compared to HA. The FNS cohort showed a shorter time-to-surgery, stay on the ICU and shorter overall hospitalization. There was a significant better outcome in postoperative mobilization and less non-surgical complications. No difference between FNS and HA in surgical complications was found; however, surgical complications in the FNS group often resulted in major conversion surgeries.

The literature suggests use of THA or HA for femoral neck fractures in non-displaced fractures due to early mobilization and less postoperative complications.[10-15,20,21] In a recent study, Lu et al.[22] found less postoperative complications and lower reoperation rate as well as better functional recovery in patients treated with HA compared to IF in non- or minimal displaced femoral neck fractures. Although this study includes old patients with comorbidities, patients with a highly impaired general condition and poor mobility were excluded. Dolatowski et al.[23] found similar results in a RCT of 219 patients with non-displaced femoral neck fractures. Despite finding HA not to be superior to screw fixation in reestablishing hip function, in their study HA showed better mobility and fewer major reoperations. Again, patients with ASA score of 4 and immobile patients were excluded. The question of the right treatment for patients with impaired general condition and poor mobility remains unanswered.

Gjertsen et al.[15] found in their study of 16,468 patients a better clinical outcome for patients operated with HA in displaced femoral neck fractures compared to IF in displaced or undisplaced femoral neck fractures with an overall 9.8% rate of reoperations and 8.4% conversion rate

Table 3. Characteristics of Patients After Femoral Neck Fracture Treatment.

Variable	Total	HA	FNS	*P*-Value
Mean time-to-surgery (hours)	19.1 ± 22.8	23.2 ± 19.1	14.3 ± 26.1	.086‡
Mean hospital stay (days, SD)	12.7 ± 5.2	15.1 ± 5.1	9.8 ± 3.8	<.001‡
ICU†	1.2 ± 2.9	2.1 ± 3.7	.2 ± 1.1	<.001‡
Mean CHARMI (SD)				
Preoperative	7.5 ± 1.8	7.1 ± 1.3	7.9 ± 2.2	
Postoperative	5.3 ± 2.3	4.0 ± 1.5	6.8 ± 2.0	
Deterioration	−2.2 ± 1.4	−2.9 ± 1.7	−1.0 ± 0.9	<.001‡
Complications (%)	42 (66.7%)	27 (79.4%)	15 (51.7%)	.237§
Surgical	8 (12.7%)	4 (11.8%)	4 (13.8%)	.692§
Non-surgical	34 (53.9%)	23 (64.7%)	11 (37.9%)	<.05§
Mortality	5 (7.9%)	3 (8.8%)	2 (6.9%)	.663§
Mean PRBC transfusions (SD)	1.2 ± 1.8	2.1 ± 2.1	.2 ± 0.6	<.001‡

§Fisher test, ‡Mann–Whitney test. †ICU: Intensive Care Unit.

into HA or THA. Dolatowski et al.[23] described high numbers of surgical complications in IF with 24 vs 8% in the HA group. The main issue was failure of fixation or nonunion. Conversion rate into HA or THA was 18%. Chammout et al.[21] reported similar numbers with higher surgical complications in the IF group and 35% of conversion surgeries. The present study showed equal surgical complication rates in both groups. Nevertheless, we found a conversion rate of 10.3% in the FNS group. It is believed that poor preoperative mobility led to less IF loosening after surgery.

In a big randomized controlled study comparing cancellous screws (CCS) with a sliding hip screw (SHS) comparable conversion rates were found. The authors reported an overall 10% implant exchange to THA and 5% to HA.[24] When it comes to fracture healing, Hu et al.[18] showed good results of bone healing of femoral neck fractures treated with the FNS. Their patients showed a bone healing after an average of 3.5 months with no cut-outs and only 10% showing shortening of the femoral neck with a mean patient age of 50 years in the FNS group. The FAITH trial showed a fracture shortening of more than 5 mm after treatment with SHS or CCS in 27% of all patients.[32] In the present study, all patients with a 3 month follow-up showed shortening of the femoral neck with 19% having shortening more than 5 mm with a mean shortening of 3.3 mm. Hu et al.[18] found comparable results with 2.4 mm. We believe that poor bone quality in the multimorbid patient cohort led to higher shortening rates. Despite that, ober 95% of the patients showed bone healing after 3 months. Nibe et al.[17] reported 100% healing rate using FNS in elderly patients in a small cohort of 25 patients.

We found a lower deterioration in the CHARMI of the FNS cohort with patients already being highly impaired in mobility. To achieve this, we used a rather holistic approach in treatment of femoral neck fractures in those patients. The aim of treatment extends from focussing on mobility and hip function to keeping a low non-surgical complication rate. 54% of our patients suffered from a non-surgical complication as UTI being the most common one. König-Leischnig et al.[25] with 50% and Muhm et al.[26] with 51.7% found comparable non-surgical complication rates. Both described postoperative anaemias as the most common complication. In our study, the HA cohort needed an average of 2.1 vs .2 PRBC after surgery due to anaemia. The higher necessity of transfusion was affiliated to the intake of haemodiluting drugs combined with the more invasive surgery. Chammout et al. as well as Dolatowski et al. showed similar results. In both studies, the HA/THA group had significant higher blood loss.[22,24] Smektala et al.[27] proclaimed in their study of 129.075 patients that an early surgical treatment leads to reduced non-surgical complication and lower mortality rate. This is in line with other literature.[21,26,28] In our study, similar results were found. As less preoperative preperations due to minimal invasive approach is necessary, the FNS cohort showed a time-to-surgery of 14.3 h with a consecutive lower non-surgical complication rate vs 23.2 h in the HA group. Literature suggests an intensive preparation for operation and interdisciplinary peri- and postoperative care in collaboration with geriatrics shows profit in general outcome of the elderly patients.[2,8,29–31,35]

The study shows several limitations. The retrospective aspect of the study comes with its inherent problems. Our system allows relatively long hospitalization and more liberal use of ICU beds. Only non-displaced femoral neck fractures classified Garden I were included. For displaced femoral neck fractures, HA and THA are still recommended. No long-term follow-up with assessments of mobility and radiographic controls after 3 months was performed, so late surgical complications are not included. No functional data after hospitalization was collected. Due to inclusion criteria, only 63 patients were included in this study. More patients would provide better statistical significance.

Conclusion

Elderly patients with numerous comorbidities and impaired mobility with femoral neck fractures need a interdisciplinary treatment focussing on fast recovery and short hospitalization to avoid potential live threatening non-surgical complications. To achieve this, internal fixation with the Femoral Neck System may be an option as a treatment option for non-displaced fractures with low non-surgical complications, shorter hospital stay and lower mortality rate. Further studies with long-term clinical and radiographic follow-ups are still necessary. Specialized geriatric assessment and rehabilitation is recommended in all geriatric patients.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

ORCID iD

Raffael Cintean https://orcid.org/0000-0001-8176-5774

Reference

1. Omsland TK, Magnus JH. Forecasting the burden of future postmenopausal hip fractures. *Osteoporos Int*. 2014;25(10): 2493-2496. doi:10.1007/s00198-014-2781-7

2. Schuetze K, Eickhoff A, Rutetzki K-S, Richter PH, Gebhard F, Ehrnthaller C. Geriatric patients with dementia show increased mortality and lack of functional recovery after hip fracture treated with hemiprosthesis. *Eur J Trauma Emerg Surg*. 2020. doi:10.1007/s00068-020-01472-4, Published online August 31.
3. Fisher A, Srikusalanukul W, Davis W, Smith P. Cardiovascular diseases in older patients with osteoporotic hip fracture: Prevalence, disturbances in mineral and bone metabolism, and bidirectional links. *Clin Interv Aging*. 2013; 8:239. doi:10.2147/CIA.S38856
4. Sennerby U. Cardiovascular diseases and risk of hip fracture. *J Am Med Assoc*. 2009;302(15):1666. doi:10.1001/jama.2009.1463
5. Smith T, Pelpola K, Ball M, Ong A, Myint PK. Pre-operative indicators for mortality following hip fracture surgery: A systematic review and meta-analysis. *Age Ageing*. 2014; 43(4):464-471. doi:10.1093/ageing/afu065
6. Bretherton CP, Parker MJ. Early surgery for patients with a fracture of the hip decreases 30-day mortality. *Bone Joint J*. 2015;97-B(1):104-108. doi:10.1302/0301-620X.97B1.35041
7. Klop C, Welsing PMJ, Cooper C, et al. Mortality in British hip fracture patients, 2000–2010: A population-based retrospective cohort study. *Bone*. 2014;66:171-177. doi:10.1016/j.bone.2014.06.011
8. Sheikh HQ, Hossain FS, Aqil A, Akinbamijo B, Mushtaq V, Kapoor H. A comprehensive analysis of the causes and predictors of 30-day mortality following hip fracture surgery. *Clin Orthop Surg*. 2017;9(1):10. doi:10.4055/cios.2017.9.1.10
9. Kabboord AD, van Eijk M, Fiocco M, van Balen R, Achterberg WP. Assessment of comorbidity burden and its association with functional rehabilitation outcome after stroke or hip fracture: A systematic review and meta-analysis. *J Am Med Dir Assoc*. 2016;17(11);1066.e21. doi:10.1016/j.jamda.2016.07.028
10. van de Ree CLP, De Jongh MAC, Peeters CMM, de Munter L, Roukema JA, Gosens T. Hip fractures in elderly people: Surgery or no surgery? A systematic review and meta-analysis. *Geriatr Orthop Surg Rehabil*. 2017;8(3):173-180. doi:10.1177/2151458517713821
11. Roberts KC, Brox WT. AAOS clinical practice guideline: Management of hip fractures in the elderly. *J Am Acad Orthop Surg*. 2015;23(2):138-140. doi:10.5435/JAAOS-D-14-00433
12. Xu W, Xue Q Long-term efficacy of screw fixation vs hemiarthroplasty for undisplaced femoral neck fracture in patients over 65 years of age: A systematic review and meta-analysis. *Orthop Surg*. 2021;13(1):3-13. doi:10.1111/os.12910
13. Tseng F-J, Chia W-T, Pan R-Y, et al. Comparison of arthroplasty vs osteosynthesis for displaced femoral neck fractures: A meta-analysis. *J Orthop Surg*. 2017;12(1):131. doi:10.1186/s13018-017-0629-5
14. Viberg B, Frøslev T, Overgaard S, Pedersen AB. Mortality and revision risk after femoral neck fracture: comparison of internal fixation for undisplaced fracture with arthroplasty for displaced fracture: A population-based study from Danish National Registries. *Acta Orthop*. 2021;92(2): 163-169. doi:10.1080/17453674.2020.1850940
15. Gjertsen J-E, Fevang JM, Matre K, Vinje T, Engesæter LB. Clinical outcome after undisplaced femoral neck fractures: A prospective comparison of 14,757 undisplaced and displaced fractures reported to the Norwegian hip fracture register. *Acta Orthop*. 2011;82(3):268-274. doi:10.3109/17453674.2011.588857
16. Stoffel K, Zderic I, Sommer C, et al. Biomechanische beurteilung der fixation von schenkelhalsfrakturen mit dem neuen femoral neck system im vergleich zu drei durchbohrten schrauben, DHS-klinge und DHS mit antirotationsschraube. *Dtsch Kongr Für Orthop Unfallchirurgie DKOU*. 2015. Published Online. doi:10.3205/15DKOU718.
17. Nibe Y, Matsumura T, Takahashi T, Kubo T, Matsumoto Y, Takeshita K. A comparison between the femoral neck system and other implants for elderly patients with femoral neck fracture: A preliminary report of a newly developed implant. J Orthop Sci. 2021;S0949-S2658(21): 00153-00156. doi:10.1016/j.jos.2021.04.016
18. Hu H, Cheng J, Feng M, Gao Z, Wu J, Lu S. Clinical outcome of femoral neck system vs cannulated compression screws for fixation of femoral neck fracture in younger patients. *J Orthop Surg*. 2021;16(1):370. doi:10.1186/s13018-021-02517-z
19. Liebl ME, Elmer N, Schroeder I, Schwedtke C, Baack A, Reisshauer A. Introduction of the charité mobility index (CHARMI)—A novel clinical mobility assessment for acute care ehabilitation. *PloS One*. 2016;11(12):e0169010. doi:10.1371/journal.pone.0169010
21. Liu Y, Chen X, Zhang P, Jiang B. Comparing total hip arthroplasty and hemiarthroplasty for the treatment of displaced femoral neck fracture in the active elderly over 75 years old: a systematic review and meta-analysis of randomized control trials. *J Orthop Surg*. 2020;15(1):215. doi:10.1186/s13018-020-01725-3
22. Choi J-Y, Cho K-J, Kim S, et al. Prediction of mortality and postoperative complications using the hip-multidimensional frailty score in elderly patients with hip fracture. *Sci Rep*. 2017;7(1):42966. doi:10.1038/srep42966
23. Chammout GK, Mukka SS, Carlsson T, Neander GF, Stark AWH, Skoldenberg OG. Total hip replacement vs open reduction and internal fixation of displaced femoral neck fractures: A randomized long-term follow-up study. *J Bone Jt Surg*. 2012;94(21):1921-1928. doi:10.2106/JBJS.K.01615
24. Lu Q, Tang G, Zhao X, Guo S, Cai B, Li Q. Hemiarthroplasty vs internal fixation in super-aged patients with undisplaced femoral neck fractures: A 5-year follow-up of randomized controlled trial. *Arch Orthop Trauma Surg*. 2017;137(1):27-35. doi:10.1007/s00402-016-2591-9

25. Dolatowski FC, Frihagen F, Bartels S, et al. Screw fixation vs hemiarthroplasty for nondisplaced femoral neck fractures in elderly patients: A multicenter randomized controlled trial. *J Bone Jt Surg*. 2019;101(2):136-144. doi:10.2106/JBJS.18.00316
26. König-Leischnig A, Klewer J, Karich B, Richter K. Alterstraumatologische patienten mit proximaler femurfraktur: Auswertung von routinedaten eines alterstraumazentrums. *Unfallchirurg*. 2017;120(8):667-674. doi:10.1007/s00113-016-0196-y
27. Muhm M, Walendowski M, Danko T, Weiss C, Ruffing T, Winkler H. [Factors influencing course of hospitalization in patients with hip fractures: Complications, length of stay and hospital mortality]. *Z Gerontol Geriatr*. 2015;48(4):339-345. doi:10.1007/s00391-014-0671-4
28. Smektala R, Hahn S, Schräder P, et al. [Medial hip neck fracture: influence of pre-operative delay on the quality of outcome. Results of data from the external in-hospital quality assurance within the framework of secondary data analysis]. *Unfallchirurg*. 2010;113(4):287-292. doi:10.1007/s00113-009-1674-2.
29. Buecking B, Bohl K, Eschbach D, et al. Factors influencing the progress of mobilization in hip fracture patients during the early postsurgical period?-A prospective observational study. *Arch Gerontol Geriatr*. 2015;60(3):457-463. doi:10.1016/j.archger.2015.01.017
30. Kammerlander C, Roth T, Friedman SM, et al. Ortho-geriatric service—A literature review comparing different models. *Osteoporos Int*. 2010;21(S4):637-646. doi:10.1007/s00198-010-1396-x
31. Grund S, Roos M, Duchene W, et al. Treatment in a center for geriatric traumatology. *Dtsch Aerzteblatt Int*. 2015;112(7):113-119. doi:10.3238/arztebl.2015.0113
32. Prestmo A, Hagen G, Sletvold O, et al. Comprehensive geriatric care for patients with hip fractures: a prospective, randomised, controlled trial. *Lancet*. 2015;385(9978):1623-1633. doi:10.1016/S0140-6736(14)62409-0.
33. Nauth A, Creek AT, Zellar A, et al. Fracture fixation in the operative management of hip fractures (FAITH): an international, multicentre, randomised controlled trial. *Lancet*. 2017;389(10078):1519-1527. doi:10.1016/S0140-6736(17)30066-1
34. Saul D, Riekenberg J, Ammon JC, Hoffmann DB, Sehmisch S. Hip fractures: Therapy, timing, and complication spectrum. *Orthop Surg*. 2019;11(6):994-1002. doi:10.1111/os.12524
35. Lohmann R, Frerichmann U, Stöckle U, Riegel T, Raschke MJ. [Proximal femoral fractures in the elderly. Analysis of data from health insurance providers on more than 23 million insured persons–part 1]. *Unfallchirurg*. 2007;110(7):603-609. doi:10.1007/s00113-007-1257-z