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RESEARCH ARTICLE

Long-term outcomes following closed reduction and internal fixation of femoral neck fractures with cannulated screws in patients under 65 years

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Abstract

Background: The long-term studies for femoral neck fractures (FNFs) in young patients treated with closed reduction and internal fixation (CRIF) are limited. This study aimed to evaluate the long-term outcomes of a group of young patients (<65 years) with FNFs treated with CRIF at our department during the last decade. We estimated treatment failure rates and identified risk factors for poor outcomes.

Methods: This retrospective cohort study included patients under 65 with a unilateral FNF treated with CRIF using partially threaded cannulated screws (CSs) between 2011 and 2021. During the latest follow-up visit, we recorded the patients' complications, re-admissions, reoperations, functional outcomes, and quality of life scores.

Results: We included 52 patients with a mean age of 53.04 years and a mean follow-up of 5.3 (range: 1.3-11) years. No non-union was recorded. Nine patients (17.3 %) underwent total hip arthroplasty (THA) due to femoral head avascular necrosis (AVN) at an average of 1.68 years following the index operation (THA group). The mean age (p =0.96), trauma type (p =0.290), sex prevalence (p =0.989), Garden classification (p =0.187), CSs number (p =0.751), and comorbidities (p =0.516) were comparable between THA and non-THA groups. Time from trauma to index surgery was significantly shorter for the THA than the non-THA group (p =0.03).

Conclusions: During a mid-to-long follow-up, 17.3 % of patients under 65 years who were treated with CRIF and CSs for FNFs developed AVN. Age, trauma type, comorbidities, time from trauma to treatment, and the number of screws did not affect the outcomes. HIPPOKRATIA 2024, 28 (1):29-34.

Keywords: Femoral neck fractures, subcapital hip fractures, long-term follow-up, closed reduction, internal fixation, cannulated screws

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Introduction

Femoral neck fractures (FNFs) are hip fractures that occur in two distinct age groups: young adults due to high-energy trauma and elderly individuals due to osteoporosis[1]. Surgical treatment is preferred for FNFs as it allows quick mobilization, reduces complications, and produces better outcomes[2]. However, the indications and types of surgical treatment for FNFs in young patients may vary considerably among orthopaedic surgeons. FNFs in young patients are typically treated with reduction under traction and internal fixation (IF) using cannulated screws (CSs) or a dynamic hip screw (DHS)[2]. It is supported that surgery needs to be performed urgently to preserve the blood flow to the femoral head[3].

The number of long-term studies investigating outcomes of patients under 65 with FNFs treated with IF is limited. These studies have reported a complication rate of 14.8-24 %[4-6]. The fracture type and the reduction quality were identified as the main risk factors for developing complications in this group of patients[7]. A meta-analysis found no significant difference in complication rates between open reduction and IF using CS or DHS for FNFs, except for a higher rate of avascular necrosis (AVN) in the CS group[8]. Most surgeons prefer using multiple CSs for undisplaced FNFs, while displaced FNFs equally prefer CSs or DHS[9]. Surgeons have yet to agree on the appropriate treatment for FNFs in young people. Therefore, it is necessary to conduct further studies to determine the most effective treatment approach.

This study reports on the mid to long-term outcomes of treating young patients (<65 years) with FNFs using closed reduction and IF (CRIF) with CSs over the last decade. Our primary aim was to estimate treatment failure rates, reoperation, and conversion from osteosynthesis to total hip arthroplasty (THA). The secondary aim was to determine the risk factors contributing to unfavorable long-term results.

Materials and Methods

This retrospective cohort study was conducted at the tertiary Academic Orthopedic department of Papageorgiou General Hospital, according to the World Medical Association Declaration of Helsinki, and was approved by the Institutional Research Board (decision No 629, date: 24/08/22). All eligible patients provided written informed consent before enrolling, and all required data was gathered from the hospital's electronic patient database.

Study population

We identified all unilateral FNFs in patients under 65 years old treated with CRIF using partially threaded CSs between 2011 and 2021. The patients were enrolled in this study if they: i) suffered from a unilateral FNF, ii) were younger than 65 years old at the time of their injury, iii) were admitted to the hospital between 2011 and 2021, and iv) were treated with CRIF using partially threaded CSs. Exclusion criteria were: i) age >65 or <18 years, ii) less than six months follow-up, iii) insufficient follow-up data, iv) conservative or other surgical treatment methods, and v) open fractures.

Operative technique

Patients were positioned supine on a radiolucent fracture table. A C-arm was used intra-operatively. Reduction manoeuvers and traction were not used for non-displaced fractures. In patients with displaced fractures, the reduction was performed in two stages. First, gentle leg traction was applied to restore the limb length. Over-reduction or sudden forceful hip movements were avoided to avoid further damage to the FN capsular vessels. The leg was rotated internally until the fracture was reduced on the axial view. The acceptable reduction was defined as having a neck-shaft angle between 130-150° or slightly valgus, with 15° of anteversion present. Retroversion and varus deformity were not accepted.

The procedures were performed using a mini-lateral hip approach by orthopedic consultants with varying experience levels. Two to four 7.0 mm or 7.3 mm partially threaded CSs were used for fracture fixation after satisfactory reduction in all cases. The aiming device was used to place CSs in a parallel, inverted triangle configuration, spreading into different femoral head segments. Unstable osteoporotic fractures were treated with more screws and washers to prevent screw penetration through the lateral cortex.

Perioperative management

All operations were performed under spinal anesthesia. Intravenous cephalosporin and aminoglycoside were administered immediately preoperatively and for 48 hours postoperatively. Patients received low molecular weight heparin for 30 days postoperatively. Patients were mobilized on the first postoperative day, ambulated with no weight bearing for six weeks, and then partial weight bearing as tolerated until the end of the third postoperative month.

Clinical and radiological assessment

Two resident orthopedic surgeons extracted data for eligible patients from the hospital's database. Demographics, comorbidities, injury, fracture and implant type, operative data, intra- and postoperative complications, and preoperative and follow-up radiographs were collected. Recently, the patients were re-evaluated at the outpatient clinic. Complications, re-admissions, and reoperations were documented. The hip disability and osteoarthritis outcome score (HOOS)[10] and the visual analog scores (VAS) were used to assess postoperative functional outcomes and quality of life. A physical examination was also performed to evaluate the hip range of motion and any painful movements. Standard anteroposterior hip and pelvis and lateral hip radiographs were performed upon the last follow-up visit. Two independent physicians not involved in the index operation evaluated the radiographs.

Statistical analysis

We used standard methods for descriptive statistics. We evaluated the data distribution normality using the Shapiro-Wilk and the Kolmogorov-Smirnov tests. Statistical tests were 2-tailed, and we set the alpha level at 0.05. We assessed continuous variables using the 2-sided independent sample t-test when normally distributed and the Mann-Whitney U-test if not normally distributed. We used the Chi-square test to compare categorical data. We performed statistical analyses using the IBM SPSS Statistics for Windows, Version 27.0 software (IBM Corp., Armonk, NY, USA).

Results

Sixty-seven patients met the inclusion criteria and were initially included in the study. Fifteen patients were lost to follow-up for social reasons unrelated to the study and were excluded. The mean follow-up was 5.3 years, ranging from 1.3 to 11 years. There were 29 female and 23 male patients. Most patients (67.3 %) were injured due to falling from a height. Twenty-three percent of the patients sustained fractures due to high-energy trauma, with 9.6 % being multi-trauma patients. The mean age of patients was 53.04 years, ranging from 19 to 65. Four patients died during the follow-up period due to reasons unrelated to the index surgery. Patients' demographics and other characteristics are presented in Table 1.

No case of non-union was recorded. Nine patients (17.3 %) were diagnosed with femoral head AVN and required conversion of their fixation to THA (THA group). The mean time from index operation to THA was 1.68 years (6 months-2.9 years). Forty-three patients had not undergone THA since the index operation (non-THA group). The mean age of patients was 52.4 (± 11.1) in the THA group and 53.1 (± 9.1) in the non-THA group.

Both groups' comparative demographics and other data are shown in Table 2 and Table 3. The mean ages of the THA and non-THA groups were not significantly different (Mann-Whitney test, p =0.96). A comparable num-

Table 1: The demographics, pre-operative baseline characteristics, and all other recorded data regarding the 52 patients under 65 years included in this retrospective cohort study.

Parameters		Values
Number*		52
Age (years)**		53 (10.4)
Sex***	Male	23 (44.2)
	Female	29 (55.8)
Trauma type***	Fall from body height	35 (67.3)
	High-energy	12 (23.1)
	Multi-trauma	5 (9.6)
Time from trauma to index operation (days)**		1.2 (1.9)
Follow-up (years) **		5.3 (2.5)
Comorbidities ***		
None		26 (50)
Chronic kidney disease/haemodialysis		2 (3.8)
Osteoporosis		8 (15.4)
Cancer		3 (5.8)
Diabetes Mellitus		1 (1.9)
Neurologic disease		1 (1.9)
Endocrine disease		3 (5.8)
Autoimmune disease		2 (3.8)
Other		6 (11.5)
Re-operation***	No (Non-THA group)	43 (82.7)
	Yes (THA group)	9 (17.3)

*: values are given as raw numbers, **: values are given as the mean with the standard deviation in brackets, ***: values are given as raw numbers with the percentages in brackets, THA: total hip arthroplasty.

ber of THAs were performed in patients under 50 and between 50-65 years (χ^2 test, p =0.74). There was no difference between THA and non-THA groups concerning the type of trauma (χ^2 test =0.290), sex prevalence (χ^2 test =0.989), the Garden classification (χ^2 test =0.187), the number of CSs used to fix the fracture (χ^2 test, p =0.751) and the presence or not of comorbidities (χ^2 =0.516) (Table 2 and Table 3). The mean time from trauma to the index surgery for the whole group was 1.29 (0-8) days; for the THA group, it was 0.22 (± 0.66) days, whereas for the non-THA group, it was 1.5 (± 2) days. The time from trauma to the index surgery was significantly shorter for the THA group than for the non-THA group (Mann-Whitney test, p =0.03) (Table 3). The mean HOOS (0.552) and VAS score (0.39) did not differ between the non-THA and the THA groups at the last follow-up (Table 3).

Discussion

Our study demonstrated good mid to long-term outcomes for young patients (<65 years old) with FNFs treated with CRIF with partially threaded CSs. At mid to long-term follow-up, 83 % of patients had good to excellent scores and did not require reoperation. Demographics, trauma type, comorbidities, time elapsed from trauma to fracture fixation, and number of screws used did not affect the outcome of the index operation.

The study's strength lies in the homogenous group of young patients assessed during a mid to long-term follow-up period. The study involved patients under 65 who underwent CRIF using partially threaded CSs at a single center. To our knowledge, only a limited number of long-term studies in the literature assess treatment outcomes in young patients with FNFs who were treated with CRIF using a single implant[4,5]. Our study investigated the mid-to-long-term clinical scenario of a young patient with an FNF undergoing CRIF with CSs.

The optimal fixation technique for FNFs in young patients remains to be determined, with open or CRIF being the first-line treatments[4]. The risk of complications for this patient group has remained relatively high over the past few decades despite various treatments[11]. The long-term outcomes of CRIF treatment for FNFs in young people are yet to be thoroughly studied. Less than ten retrospective studies have been published, with their sample size ranging from 27-250 patients and the mean follow-up ranging from 2-12.5 years[4-6,11-14]. CSs are typically used for primary fixation, although some studies have also employed DHS. At a mean follow-up of 5.2 years, our study re-evaluated 52 patients, one of the largest patient cohorts in the literature.

Our study has shown a success rate comparable to other studies reported in the field[4-6,11-14]. The literature reports non-union and AVN rates between 10 % to 30 % following FNF reduction and IF in young patients[4-6,11-14]. A meta-analysis of 564 FNFs treated with IF supported an overall non-union incidence of 8.9 % and an AVN incidence of 23 %[15]. These results are comparable to our findings. The absence of non-union cases in our study might be because all included patients underwent closed reduction and internal fixation without further compromising the femoral head's blood supply during the operation.

Due to the retrospective design of the studies and the multifactorial nature of complications, it is difficult to identify patients at risk for complications. Poor outcomes after fixation of FNFs have been associated with demographics and other comorbidities[4,6,16]. There may be an age limit beyond which the risk of complications after surgery increases[4]. In our study, however, there was no difference in complication risk between individuals under 50 and those aged 50-65. Patient-related risk factors and lifestyle may not increase the risk of complications. However, kidney or respiratory failure, smoking, alcohol abuse, high BMI, and the American Society of Anesthesiologists (ASA) score appear to increase the risk of revision following FNF fixation in all age groups[4,6,16]. Our study found that the patients' demographics and comorbidities did not significantly impact the outcomes.

High-energy trauma may cause damage to the capsule and femoral neck vessels, increasing the risk of complications. However, in our study, it was not possible to

Table 2: Comparative demographic and pre-operative data between the total hip arthroplasty (THA) and the non-THA groups.

Parameter		Group		
		THA group	Non-THA group	p
Age (years)*		52.4 (11.1)	53.2 (9.7)	0.962@
Sex**	Male	4	19	0.989 #
	Female	5	24	
Trauma type**	Fall from body height	6	29	0.290#
	High energy	1	11	
	Multi-trauma	2	3	
Garden classification**	I	1	12	0.187@
	II	2	15	
	III	2	10	
	IV	4	6	
Comorbidities **				
None		5	21	0.516#
Chronic kidney disease/haemodialysis		0	2	
Osteoporosis		1	7	
Cancer		2	1	
Diabetes Mellitus		0	1	
Neurologic disease		0	1	
Endocrine disease		0	3	
Autoimmune disease		0	2	
Other		1	5	
Alcoholism	Yes	0	1	0.644#
	No	9	42	
Smoking	Yes	2	19	0.222#
	No	7	24	

THA: total hip arthroplasty, *: values are given as the mean with the standard deviation in brackets, **: values are given as raw numbers, @: test was performed using the Mann-Whitney test, #: test was performed using χ^2 test.

Table 3. Comparative peri- and post-operative data and functional scores between groups

Parameter		Group		
		THA group	Non-THA group	p
Time from trauma to index operation (days)**		0.22 (0.6)	1.5 (2)	0.03@
Number of screws used to fix the fracture*	2	2	6	0.751%
	3	7	36	
	4	0	1	
Follow-up**		5.3 (2.7)	5.3 (2.4)	0.832$
VAS score**		1.8 (0.7)	2.0 (1.8)	0.390@
HOOS score**		89 (5.6)	85.6 (16.1)	0.552@

THA: total hip arthroplasty, *: values are given as raw numbers, **: values are given as the mean with the standard deviation in brackets, @: test was performed using the Mann-Whitney test, %: test was performed using χ^2 test, $: tests were performed using independent-sample t-test.

establish a significant relationship between the type of trauma and the risk of developing complications because only a small number of young patients with FNF sustain their injury following a high-energy trauma[6,17]. Fracture displacement may be related to the type of trauma, with higher displacement indicating greater force. The fracture displacement may increase vascular damage risk while reducing the possibility of successful fracture reduction. Thus, it is a significant prognostic factor in predicting unfavorable outcomes[16,18,19]. In this study, the trauma type did not impact the complication risk, and the AVN risk was similar between undisplaced and displaced fractures.

The time elapsed from injury to surgery has been extensively studied as an independent risk factor for poor outcomes in younger patients. Previous studies have shown that the early reduction and IF of FNFs (within 6-24 hours postinjury) can improve the blood supply to the femoral head and reduce the AVN risk[20-22]. However, several recent studies found no significant difference in the incidence of femoral AVN between early and late fix-

ation for patients with FNFs, regardless of the cut-off value used (12-48 hours)[5,6,10-13,23-25]. Interestingly, the group that underwent THA had a significantly shorter mean time from injury to index surgery in our study. However, this finding cannot be considered conclusive due to our study's small number of THA cases. The femoral head blood supply is primarily affected by the momentary detonation force at the time of injury, but it appears to be unrelated to the timing of the surgery.

The preoperative Garden classification and poor fracture reduction quality have been reported as independent risk factors for complications after FNF fixation[16,18]. Insufficient reduction of a fracture, rotation of the femoral head, and varus deformity can increase shearing forces on the fracture surface, which hinder blood vessel reconstruction around the femoral head[5]. According to another study, there is no correlation between the AVN rate and the reduction of FNFs[11]. Our research found that the Garden classification was not different between the THA and non-THA groups. All FNFs were adequately reduced and cannot be further examined in our research.

The implant type used and the amount of weight-bearing after surgery can impact the stability of the fixation and the outcomes. Studies supported the use of DHS in more unstable fracture patterns[2]. Our study was not designed to examine the effects of different types of implants and the weight-bearing. All patients followed a similar postoperative rehabilitation protocol. Typically, three CSs were used, while four CSs were inserted into the more unstable FNFs. The number of screws used was unrelated to the complication risk in our study.

This retrospective study has several limitations. Due to the extended follow-up period, several patients were lost. Sometimes, the hospital's database data were insufficient or unavailable. The initial operations were performed by several consultant orthopedic surgeons with different levels of expertise, which may have affected the outcomes. Due to the rarity of FNFs in young adults, only 52 patients were included in the study, making statistical analysis challenging despite the long data collection and analysis. The success of the index surgery also depends on factors not recorded, such as BMI and post-surgery activity levels.

Conclusions

This study demonstrated that 17 % of patients younger than 65 with FNFs treated with CRIF developed AVN at mid to long-term follow-up. The complication rate seen in this study is consistent with the rates previously reported in the literature. The outcome of the index operation was not affected by factors such as the patient's age, trauma type, comorbidities, the time elapsed from trauma to fracture fixation, or the number of screws used. Therefore, CRIF should be the primary treatment option for these types of fractures.

Conflict of interest

The authors declare no conflicts of interest.

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