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Comparative Study for Osteosynthesis of Femoral Neck Fractures: Cannulated Screws versus Femoral Neck System

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Purpose: The purpose of this study is to compare the radiological results of fixation using the femoral neck system (FNS) and cannulated screw (CS) for treatment of femoral neck fractures.
Materials and Methods: A retrospective study of patients with femoral neck fractures who underwent internal fixation and had follow-up of more than six months from 2010 to 2020 was conducted. A total of 87 patients were enrolled in the study. The FNS group included 20 patients and the CS group included 67 patients. Classification of fractures was performed according to Garden and Pauwels classification. Operation time, intraoperative blood loss, sliding distance of the implant, lateral soft tissue irritation caused by implants, and complications were evaluated.
Results: The mean operation time was 40.30 minutes in the FNS group and 46.84 minutes in the CS group. The mean intraoperative bleeding volume was 51.25 mL in the FNS group and 72.16 mL in the CS group. Bone union was achieved in 18 patients in the FNS group (90.0%) and in 61 patients in the CS group (91.0%). The mean sliding distance of the implant was 4.06 mm in the FNS group and 3.92 mm in the CS group. No patients in the FNS group and 12 patients in the CS group complained of soft tissue irritation.
Conclusion: A shorter operative time, less intraoperative bleeding, and less irritation of soft tissue were observed in the FNS group. FNS could be an alternative to CS for fixation of femoral neck fractures.

Key Words: Femur, Neck fracture, Femoral neck system, Cannulated screw

INTRODUCTION

The presence or absence of displacement and age is an important preoperative consideration in determining the treatment of a femoral neck fracture. Recent advancements in surgical techniques, implant design, and longevity of hip arthroplasty have led to reduced stress for surgeons in management of displaced femoral neck fractures in the elderly[1-3]. However, in cases where internal fixation is required, such as younger patients and elderly patients with non-displaced femoral neck fractures, rigorous internal fixation is essential. Previously used fixation devices have included the hook pin, Knowles pin, and Watson-Jones nail[4-6]. More recently, a cannulated screw (CS) or a sliding hip screw (SHS) has

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been the usual choice of implant. Although SHS provides better stability in patients with unstable fractures, an extensive skin incision and other devices for maintenance of rotational stability, such as an anti-rotational screw, are required. A new internal fixation device for fixation of femoral neck fractures, known as the femoral neck system (FNS), was introduced in 2017. It offers dynamic fixation of femoral neck fractures, combining the advantages of angular stability with a minimally invasive surgical technique[7]. Possible replacement of previously used instruments with the newly developed FNS, which offers various theoretical advantages, could be an important consideration for clinicians in performance of surgery.

The purpose of this study was to compare the results of fixation using FNS and CS for treatment of femoral neck fractures.

MATERIALS AND METHODS

This study was approved by the Institutional Review Board of Daegu Fatima Hospital (IRB No. DFH 2022-05-002), and informed consent was waived by the IRB.

Electronic medical records and radiographs of patients who underwent internal fixation for treatment of femoral neck fractures from July 2010 to August 2020 at our hospital were reviewed. A total of 155 patients were identified. FNS has been used consecutively since July 2019. After exclusion of pediatric patients, patients with a femoral shaft fracture or hip dislocation and less than six months follow-up, and patients for whom a compression hip screw or cephallomedullary nail was used, 87 patients were included in the study. The FNS group included 20 patients, and the CS group included 67 patients.

Basic patient demographics including age, sex, body mass index (BMI), mechanism of injury, bone quality, and Garden and Pauwels classification were examined[8,9]. According to the Garden classification, type I and II fractures were classified as non-displaced fractures, and type III and VI fractures were classified as displaced fractures. A low energy injury is defined as a simple fall while high energy injury includes motor vehicle accidents, fall from height, etc. Bone quality was classified as normal, osteopenia, and osteoporosis according to World Health Organization criteria[10]. Operation time, intraoperative blood loss, time to bone union, sliding distance of the screw and bolt, irritation of lateral soft tissue caused by implants, fixation failure, nonunion, avascular necrosis (AVN), and infection were assessed for measurement of outcome. Foss's formula was used for calculation of intraoperative blood loss[11]. Bone union was described by Corrales et al.[12] as follows: clinical absence of pain at the fracture site on both palpation and weight bearing and radiological evidence of bridging of three or more cortices on two different views. We believe that this is a reasonable description of united bone and this definition was used for the current study. Measurement of the sliding distance of the implant was performed using the method reported by Stockton et al.[13].

Reduction and fixation of the fracture was performed on the fracture table under fluoroscopic guidance.

Three partially threaded CSs (7.0 mm or 7.3 mm) were inserted in a parallel inverted triangle configuration (inferior, posterosuperior, and anterosuperior). A washer was used for the inferior screw to prevent penetration of the screw through the lateral cortex, which might increase the maximal insertion torque of the lag screw, resulting in improvement of screw purchase in the femoral head[14,15].

The surgical procedure for FNS is as follows. After making a skin incision, a 3.2 mm Steinmann pin was inserted temporally at the superior aspect of the femoral head to prevent rotation of the fracture. A central guide pin located in the center of the femoral head in anteroposterior and lateral view was inserted using a 130˚ angle guide. Following measurement of the length of the inserted central guide wire, a hole was made along the central guide wire using a cannulated drill. Assembly of the bolt and side plate was performed using the insertion handle on the scrub table. Following insertion of the bolt and side plate through the central guide pin, an anti-rotation screw and distal locking screw were finally inserted.

Sitting and wheelchair ambulation was encouraged immediately after surgery. Monthly follow-up of patients after surgery continued until bone union was achieved. Weight-bearing was not allowed until confirmation of bone union on radiographs. Standard radiographs including hip joint anteroposterior, lateral, and cross table axial view were obtained at the follow-up visit.

Statistical analysis was performed using the chi-squared test and student t-test. Statistical significance was accepted for a P-value <0.05. Data analysis was performed using IBM SPSS Statistics (ver. 22.0; IBM, Armonk, NY, USA).

RESULTS

The basic demographic and preoperative data for the two groups are shown in Table 1. No statistical significance regarding sex, age, BMI, preoperative Garden classifica-

tion, injury mechanism, and bone quality was observed between the two groups. However, the CS group included significantly fewer Pauwel type III patients (P=0.031).

The mean surgical time was 40.30±8.53 minutes (range, 30-65 minutes) in the FNS group, and 46.84±11.60 minutes (range, 33-87 minutes) in the CS group (P=0.022). A longer mean follow-up period (P=0.000) was observed in the CS group compared with the FNS group. The mean intraoperative blood loss was 51.25±16.05 mL (range, 40-90 mL) in the FNS group and 72.16±31.55 mL (range, 40-150 mL) in the CS group (P=0.000). A significantly shorter mean surgical time and significantly less mean intraoperative blood loss was also observed in the FNS group compared with the CS group.

The mean sliding distance of the screw was 4.06±4.26 mm (range, 0.1-10.8 mm) in the FNS group and 3.92±3.93 mm (range, 0-21.7 mm) in the CS group (P=0.889). The FNS group included no cases of soft tissue irritation related to sliding of the screw or bolt; however, the CS group included 12 cases. The bone union rate was 90.0% (18/20) in the FNS group and 91.0% (61/67) in the CS group. The mean time to bone union was 10.50±2.07 weeks (range, 8-14 weeks) in the FNS group and 11.21±4.95 weeks (range, 8-28 weeks) in the CS group. Time to bone union (P=0.556) and bone union rate (P=0.887) showed no statistical significance. Treatment with hip arthroplasty was administered in all cases of fixation failure and nonunion. The FNS group included no case of AVN of the femoral head, while the CS group included seven cases. Fig. 1 shows an important clinical data of all patients in two groups.

Treatment with hip arthroplasty was also administered in all cases of AVN after fixation. The FNS group included no cases of infection and the CS group included one case, which was superficial and treated with surgical debridement and antibiotics administration All clinical and radiological outcomes are shown in Table 2.

DISCUSSION

Internal fixation is the treatment of choice for undisplaced femoral neck fractures regardless of age and for displaced fractures in younger patients[16]. Although various devices for internal fixation have been utilized in the past, wide use of CS and SHS has recently been reported.

Compared with an SHS, fixation using CS offers several advantages, including a technique with relatively minimal invasiveness, shorter operative time, and less intraoperative blood loss[17-19]. Fixation using SHS offers greater mechanical stability for resistance to the increased shear forces; therefore, it is recommended for treatment of Pauwel type III,

Table 1. Basic Demographic and Preoperative Data

Variable	FNS (n=20)	CS (n=67)	P-value	x^2
Sex			0.258	1.280
Male	5	26		
Female	15	41		
Age (yr)	54.70±12.08	57.99±12.33	0.296	-
Body mass index (kg/m^2)	22.81±2.64	22.38±2.70	0.082	-
Classification				
Garden			0.631	0.231
I+II	14	43		
III+IV	6	24		
Pauwel			0.031*	4.656
I+II	15	62		
III	5	5		
Injury mechanism			0.098	2.743
High energy	15	60		
Low energy	5	7		
Bone quality			0.792	0.465
Normal	5	22		
Osteopenia	8	23		
Osteoporosis	7	22		

Values are presented as number only or mean±standard deviation.
FNS: femoral neck system, CS: cannulated screw.
* P<0.05.

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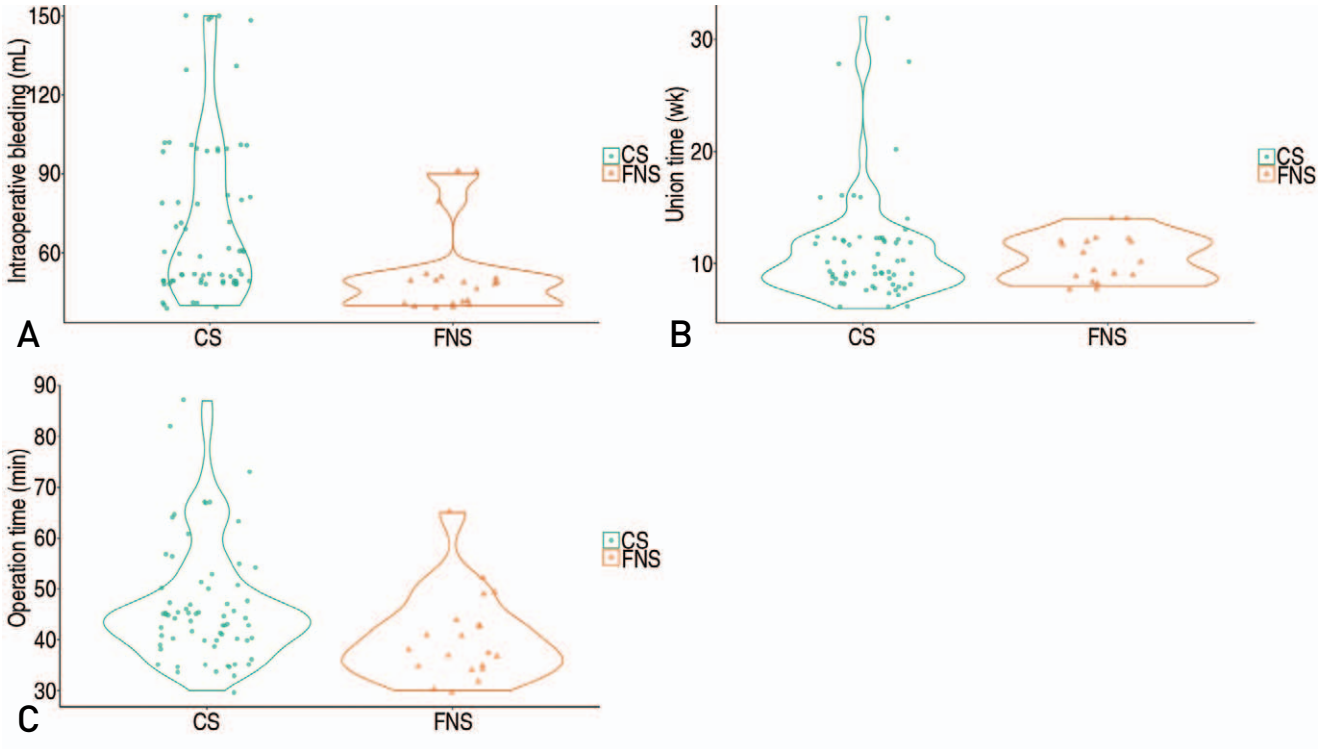

Fig. 1. An important clinical data of all patients in two groups. Intraoperative bleeding volume (**A**), bone union time (**B**), and operation time (**C**).
CS: cannulated screw, FNS: femoral neck system.

Table 2. Clinical and Radiological Outcomes of Study Groups

Variable	FNS (n=20)	CS (n=67)	*P*-value
Operation time (min)	40.30±8.53	46.84±11.60	0.022*
Mean follow-up (mo)	8.45±3.05	25.12±22.76	0.000*
Intraoperative blood loss (mL)	51.25±16.05	72.16±31.55	0.000*
Sliding distance (mm)	4.06±4.26	3.92±3.93	0.889
Lateral soft tissue irritation	0	12	0.060
Bone union time (wk)	10.50±2.07	11.21±4.95	0.556
Fixation failure and nonunion	2	6	0.887
Osteonecrosis	0	7	0.132
Infection	0	1	0.583

Values are presented as mean±standard deviation or number only.
FNS: femoral neck system, CS: cannulated screw.
* $P<0.05$.

basicervical, and highly comminuted unstable fracture patterns[20-23].

FNS, a novel implant for fixation of femoral neck fractures, has been available for use in Korea since 2019. It enables controlled impaction and rotational stability is provided by an anti-rotational screw and angular stability by a side plate fixed by a locking screw[7].The distal locking screw is inserted in the subtrochanteric region regardless of the length of the side plate (one and two hole are available), which may be associated with a subtrochanteric stress fracture. However, a biomechanical study found no association between the FNS construct and increased incidence of iatrogenic subtrochanteric fractures[24]. Another study reported an association between a screw start point that is distal to the lesser trochanter with subtrochanteric femur fractures in the osteoporotic subset. In addition, starting the distal-most screw distal to the lesser trochanter resulted in decreased load to failure[25]. The surgeon must keep in mind

that a hole for the bolt should be made with insertion of the locking screw in the center of the femoral diaphysis in order to prevent a potential subtrochanteric fracture (Fig. 2).

Except for Pauwel classification and mean follow-up period, no differences in basic preoperative data (Table 1) were observed between the two groups. Five of 67 patients (7.5%) in the CS group and five of 20 patients (25.0%) in the FNS group had a Pauwel type III fracture. Because SHS is the preferred type of fixation for Pauwel type III fractures during the period of CS fixation, it is thought that selection bias was included.

In the current study, a significantly shorter operation time and significantly less intraoperative blood loss were observed in the FNS group. Insertion of one central guide wire in an ideal position during FNS fixation enables easy performance of the subsequent surgical procedure using the insertion guide. Therefore, more time is required for the insertion of three parallel CSs, and it is expected that the amount of intraoperative bleeding will be greater than that of the FNS group. Because FNS was used from 2019, a statistical significance in the follow-up period was observed between the two groups.

Significantly greater irritation of lateral soft tissue by the screw head resulting from impaction of the fracture site was observed in the CS group. Stiasny et al.[26] reported that irritation of subtrochanteric soft tissue caused by cancellous screws was the primary reason that patients underwent revision. Following fixation using FNS, there is enough space for the bolt to slide 15 mm within the barrel of the side plate. Although the sliding distance was similar between the two groups, irritation of lateral soft tissue as in FNS does not occur when the sliding distance of the bolt and anti-rotational screw is less than 15 mm (Fig. 2).

Nibe et al.[27] reported shortened surgical time with comparable blood loss with internal fixation using the FNS in elderly patients with femoral neck fractures, and a lower reoperation rate was observed for patients using the FNS compared with those using other implants including CS. By contrast, Hu et al.[28] reported a longer operation time and greater perioperative blood loss with fixation using FNS compared with fixation using CS.

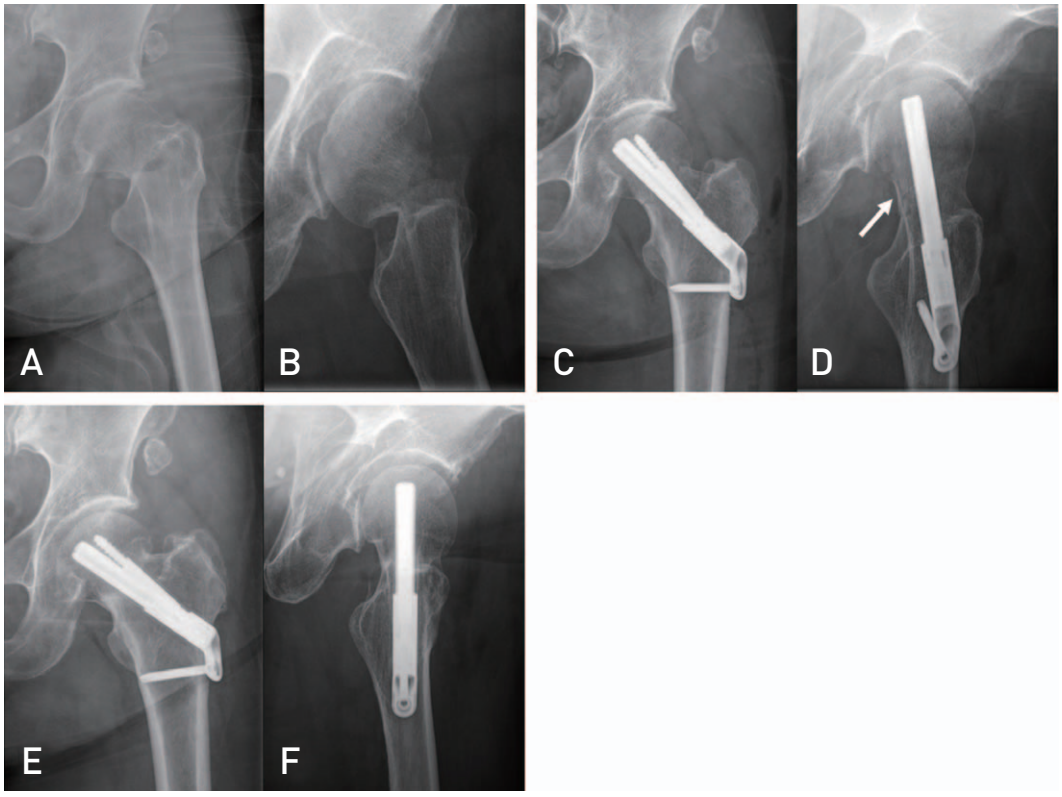

Fig. 2. A 66-year-old female patient diagnosed with a displaced femoral neck fracture on anteroposterior (**A**) and lateral view (**B**). An immediate postoperative X-ray shows acceptable reduction and fixation with femoral neck system (**C**, **D**). A white arrow indicates a comminution of the posterior cortex. An 18-month follow-up radiograph shows union of the fracture with slight shortening of the femoral neck with concomitant sliding of the bolt within the barrel of the side plate. There is no protrusion out of the side plate despite sliding of the bolt and an anti-rotation screw. Placement of the distal locking screw at a central location in the femoral diaphysis is important for prevention of a potential subtrochanteric fracture (**E**, **F**).

From a biomechanical point of view, FNS is an acceptable alternative for treatment of unstable femoral neck fractures, offering the advantages of a minimally invasive implant with stability comparable to that of the two-holes DHS (dynamic hip screw) systems and superior to CSs[7]. As in biomechanical studies, clinical findings also demonstrated that there were fewer cases of fixation failure and subsequent nonunion[26,27]. Findings of the current study showed no statistical significance in bone union time, fixation loss, and nonunion between the two groups. Based on the findings of our study, FNS could be considered as an alternative treatment for fractures that are indications for fixation using CS.

Wide-ranging incidence of AVN after fixation of a femoral neck fracture from 7% to 25.3% has been reported[19,29,30]. In the current study, the incidence of AVN was 7/67 (10.4%) in the CS fixation group and 0/20 (0%) in the FNS fixation group. It is believed that AVN was not detected because of the short follow-up period in the FNS group. The incidence of AVN in FNS fixation will be accurately determined with long-term follow-up.

Our study has several limitations. First, it is a retrospective study and there is a selection bias, particularly in the CS group. The relatively small number of patients in the FNS group is a limitation that could be overcome through conduct of a long-term multicenter study. Clarification regarding the incidence of AVN in the FNS group could also be attained through conduct of a long-term follow-up. Because both groups included only a small number of unstable cases that required SHS fixation, the usefulness of FNS fixation for treatment of unstable fractures could not be determined.

Despite these limitations, our study is the first report comparing CS fixation with FNS fixation in Korea. Conduct of future studies will be required in order to clarify the potential for replacement of SHS fixation with FNS fixation and its effect on the occurrence of AVN.

CONCLUSION

Similar fixation failure and bone union rates were obtained from use of two internal fixation devices. However, shorter operative time, less intraoperative bleeding, and less soft tissue irritation were obtained with use of FNS fixation. FNS could be considered as an alternative to CS for fixation of femoral neck fractures.

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CONFLICT OF INTEREST

The authors declare that there is no potential conflict of interest relevant to this article.

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