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Femoral Neck System (FNS): A Biomechanical Strong Solution for Stable Fixation in Basi cervical Neck of Femur Fractures

Dr. Muhammad Hasnat[1], Dr. Md. Iftekharul Alam[2], Dr. Md. Emdadul Hoque Bhuyan[3], Dr. Kazi Mohammad Hannanur Rahman[4], Dr. Md. Ziaul Hasan[5], Dr. Mostakim Billah[6], Dr. Md. Sarwar Jahan[7], Dr. Md. Ehteshamul Alam[8], Dr. Tanzirul Islam[9]

1. Assistant Registrar, Department of Orthopaedic, National Institute of Traumatology and Orthopaedic Rehabilitation (NITOR), Dhaka, Bangladesh.
2. Assistant Professor, Department of Orthopaedic Surgery (Hand and Microsurgery), National Institute of Traumatology & Orthopaedic Rehabilitation (NITOR), Dhaka, Bangladesh
3. Assistant Professor, National Institute of Traumatology and Orthopaedic Rehabilitation (NITOR), Dhaka, Bangladesh.
4. Assistant Professor, Department of Orthopaedic Surgery, National Institute of Traumatology & Orthopaedic Rehabilitation (NITOR), Dhaka, Bangladesh
5. Department of Orthopaedic Surgery, National Institute of Traumatology and Orthopaedic Rehabilitation (NITOR), Dhaka, Bangladesh.
6. Jr. Consultant, Department of Analgesia and Critical Care Medicine, Bogra 250 bed Mohammad Ali District Hospital, Bogura, Bangladesh.
7. Assistant Professor (Spine Surgery), National institute of Traumatology & Orthopedic Rehabilitation (NITOR), Dhaka, Bangladesh.
8. Medical Officer, Dhaka Medical College, Dhaka, Bangladesh.
9. Lecturer, South Apollo Medical College & Hospital, Barishal, Bangladesh.

ARTICLE INFO **ABSTRACT** **ORIGINAL RESEARCH ARTICLE**

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Background: Due to their rarity and probable instability, basicervical femoral neck fractures whose frequency ranges from 1.8 to 7.6% present difficulties and have higher repair failure rates than intertrochanteric fractures. Even though the fracture site is extracapsular, surgical treatment is still difficult. **Objectives:** This study was done for assessment of femoral neck system (FNS) as a biomechanical strong solution for stable fixation in basicervical neck of femur fractures. **Methods:** The cross-sectional Observational study was conducted in the Department of Orthopedic, National Institute of Traumatology and Orthopedic Rehabilitation (NITOR) from June 2022 to May 2023. A total of 30 patients of both sexes were included in the study. Data was collected over a period of 12 months and analyzed by appropriate computer based programmed software Statistical Package for the Social Sciences (SPSS), version 24. **Results:** In this study, most of the respondents 18 (60.7%) lies between 51 years to 60 years. Mean ± SD of the respondents was 52.41 ± 6.75 years. More than half of the patient 19 (63.30%) were male and 11 (36.70%) patients were female. Most of the patients 17 (56.7%) BMI were in between normal range, 7 (23.3%) were underweight and 6 (20.0%) were overweight. Mean ± SD of the patients BMI was 25.3 ± 5.4 kg/m2. About 12 (40.0%) patients had type III garden fracture, 9 (30.0%) patients had type II garden fracture, and 9 (30.0%) patients had type I garden fracture. Most of the patients 21 (70.0%) had type II Pauwels fracture. The average surgery time was 76.65 ± 34.25 min, the blood loss was 67.45 ± 51.43 ml, the Preoperative Harris Score was 22.25 ± 4.56 and the Postoperative Harris Score was 83.80 ± 5.78, the healing time was 3.33 ± 0.60 and Femoral neck shortens was 2.20 ± 1.41mm. Non-union had occurred in case of 3 (10.0%) patients, Femoral neck shortening had occurred in 2 (6.7%) case and Femoral neck necrosis had occurred in 1 (3.3%) case. **Conclusion:** FNS treatment can produce good clinical outcomes for patients with basi cervical femoral neck fractures. FNS exhibits much greater overall construct stability and superior biomechanical qualities.

Key words: Femoral neck system, Femoral neck fracture, Harris Hip Score, Surgical fixation devices

Corresponding author
Islam AMA*

INTRODUCTION:

Significant morbidity and death are caused by femoral neck fractures (FNFs), a common injury in orthopedic treatment [1]. Although FNFs are most prevalent in the elderly, we should pay attention to how they are treated in patients who are very young. High-energy trauma, such as falls from heights or high-speed car crashes, is typically the cause of femoral neck fractures in young people [2]. The objective of surgical treatment for young patients is to achieve bone healing, prevent femoral head necrosis, and preserve the femoral head as much as feasible. Therefore, open or closed reduction and internal fixation (CRIF) is preferred by young patients with FNFs [2, 3]. A favorable prognosis and function depend on anatomical reduction and efficient fixation [4].

Although open reduction and internal fixation (ORIF) and CRIF are currently the most well-known therapeutic options for young patients with FNFs, postoperative problems such femoral neck shortening, fracture nonunion, and avascular necrosis (AVN) are still common. In younger patients, the frequency of nonunion was 9.3% and the incidence of AVN was 14.3%, according to a meta-analysis that examined 1558 FNFs from 41 studies [2]. Medical difficulties and a significant socioeconomic burden accompany this. When treating FNFs, orthopedic surgeons must select the best implant, particularly for younger patients.

CRIF or ORIF with dynamic hip screws (DHS) or cannulated compression screws (CCS) are the preferred treatments for young adults [4]. In clinical practice, cancellous lag screws are the most commonly utilized of these internal fixations. Three parallel cancellous lag screws placed in an inverted triangle shape at or above the lesser trochanter level can be used to treat Pauwel type I and the majority of type II fractures. A DHS provides more mechanical stability to withstand the increased shearing pressures produced and ought to be utilized in lieu of cancellous screws for Pauwel type III, basicervical, and heavily comminuted unstable fracture patterns [3, 4].

The femoral neck system (FNS), a novel minimally invasive implant, was created recently for the dynamic fixation of FNFs. The implant's tiny side plate allows for a smaller implant footprint while providing fixation to the femoral shaft. To enable these parts to glide together along the plate barrel for dynamic fixation, the femoral head is fixed using a screw that is locked into a bolt.

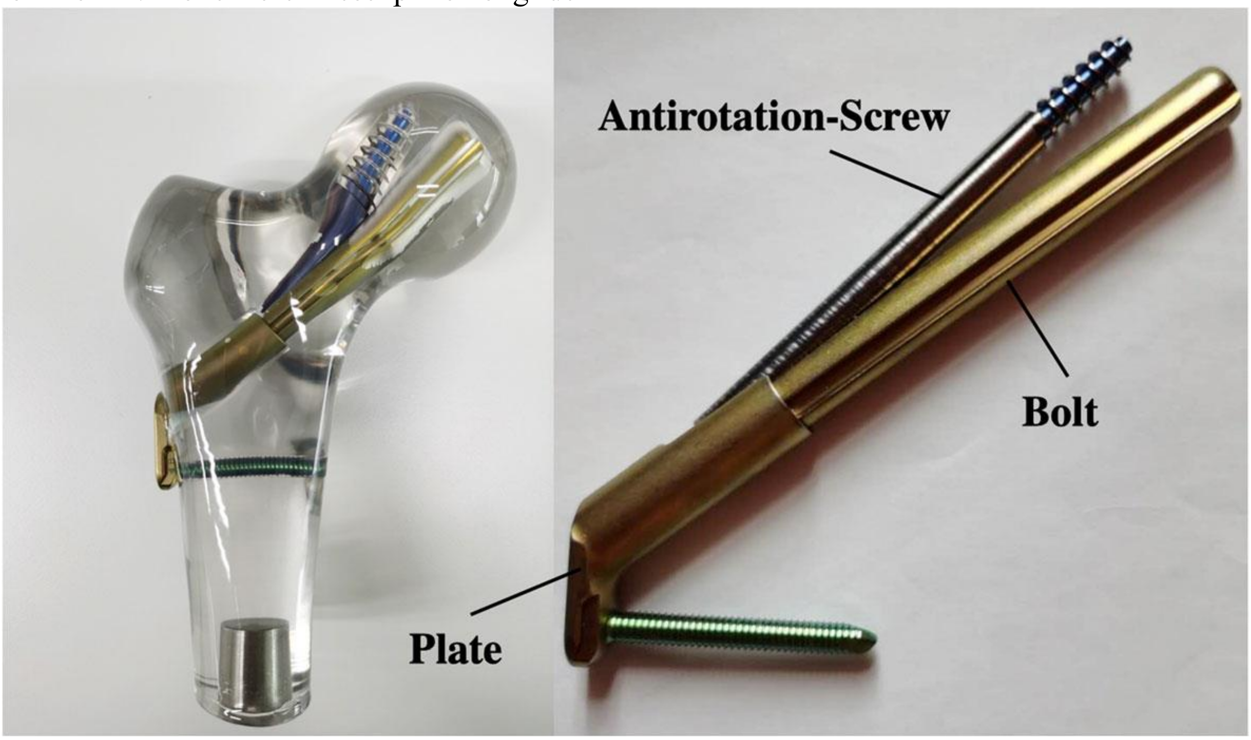

Figure I: Schematic diagram of femoral neck system

METHODOLOGY:

The cross-sectional Observational study was conducted in the Department of Orthopedic, National Institute of Traumatology and Orthopedic Rehabilitation (NITOR) from June 2022 to May 2023. A total of 30 subjects of both sexes were included in the study. Purposive sampling was done according to the availability of the patients who fulfilled the selection criteria. Face to face interview was done to collect data with a semi-structured questionnaire. After collection, the data were checked and cleaned, followed by editing, compiling, coding, and categorizing according to the objectives and variables to detect errors and to maintain consistency, relevancy and quality control. Statistical evaluation of the results used to be obtained via the use of a window-based computer software program devised with Statistical Packages for Social Sciences (SPSS-24).

RESULTS:

Table I shows that, most of the respondents 18 (60.7%) lies between 51 years to 60 years. Mean ± SD of the respondents was 52.41 ± 6.75 years

Table I: Distribution of the patients according to age (n = 30)

Age group	Frequency	%
40 – 50 years	7	23.3
51 - 60 years	18	60.0

>60 years	5	16.7
Total	30	100.0
Mean ± SD: 52.41 ± 6.75 years		

Figure I shows that, more than half of the patient 19 (63.30%) were male and 11 (36.70%) patients were female.

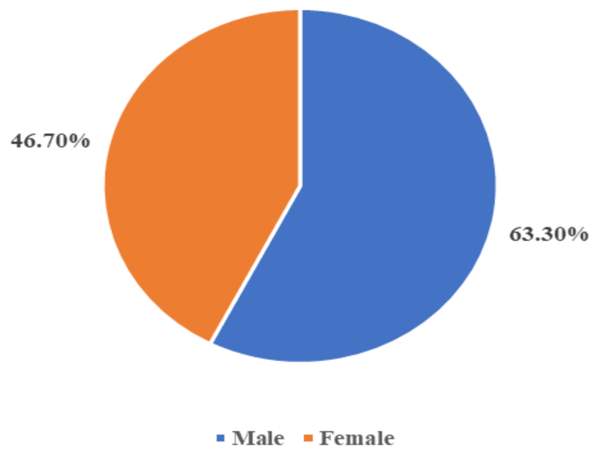

Figure I: Distribution of the patients according to sex (n=30)

Table II shows that, most of the patients 17 (56.7%) BMI were in between normal range, 7 (23.3%) were underweight and 6 (20.0%) were overweight. Mean ± SD of the patients BMI was 25.3 ± 5.4 kg/m2

Table II: Distribution of the patients according to Body mass index, kg/m2 (n = 30)

Body mass index	Frequency	%
Underweight (18.5 – 24.9)	7	23.3
Normal (25 – 29.9)	17	56.7
Overweight (more than 30)	6	20.0
Total	30	100.0
Mean ± SD: 25.3 ± 5.4 kg/m^2		

Table III shows that, about 12 (40.0%) patients had type III garden fracture, 9 (30.0%) patients had type II garden fracture and 9 (30.0%) patients had type I garden fracture

Table III: Distribution of the patients according to Garden type (n=30)

Garden type	Frequency	%
Type I	0	0.0
Type II	9	30.0
Type III	12	40.0
Type IV	9	30.0
Total	30	100.0

Table IV shows that, most of the patients 21 (70.0%) had type II Pauwels fracture

Table IV: Distribution of the patients according to Pauwels type (n = 30)

Pauwels type	Frequency	%
Type I	2	6.7
Type II	21	70.0
Type III	7	23.3
Total	30	100.0

eTable V shows that, the average surgery time was 76.65 ± 34.25 min, the blood loss was 67.45 ± 51.43 ml, the Preoperative Harris Score was 22.25 ± 4.56 and the Postoperative Harris Score was 83.80 ± 5.78, the healing time was 3.33 ± 0.60 and Femoral neck shortens was 2.20 ± 1.41mm

Table V: Distribution of the patients according to perioperative characteristics (n = 30)

Variables	Mean ± SD
Operation time (min)	76.65 ± 34.25
Perioperative Blood loss (ml)	67.45 ± 51.43
Preoperative Harris Score	22.25 ± 4.56
Postoperative Harris Score	83.80 ± 5.78
Healing time (months)	3.33 ± 0.60
Femoral neck shortens (mm)	2.20 ± 1.41

Table VI shows that, non-union had occurred in case of 3 (10.0%) patients, Femoral neck shortening had occurred in 2 (6.7%) case and Femoral neck necrosis had occurred in 1 (3.3%) case

Table VI: Distribution of the patients according to complications (n=30)

Complications	Frequency	%
Non-union	3	10.0
Femoral head necrosis	1	3.3
Femoral neck shortens	2	6.7
Screw cutout	0	

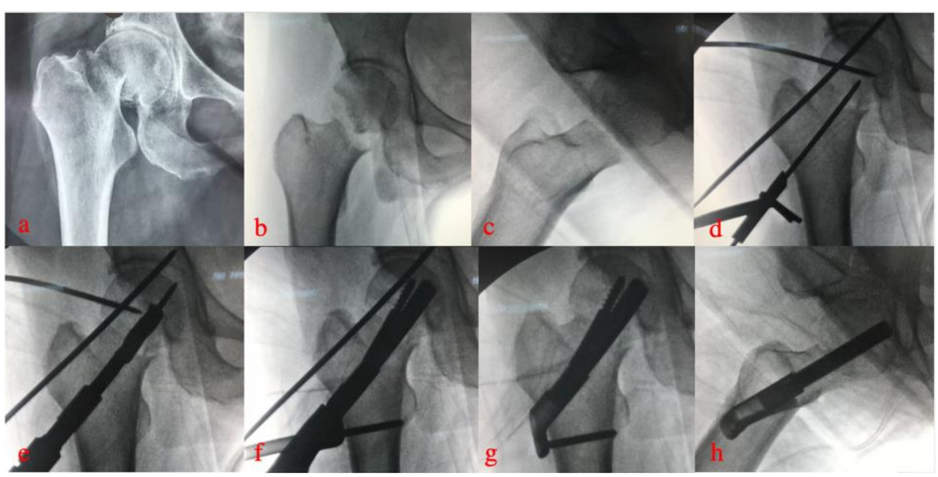

Figure II: Surgical procedures of treating femoral neck fracture with FNS

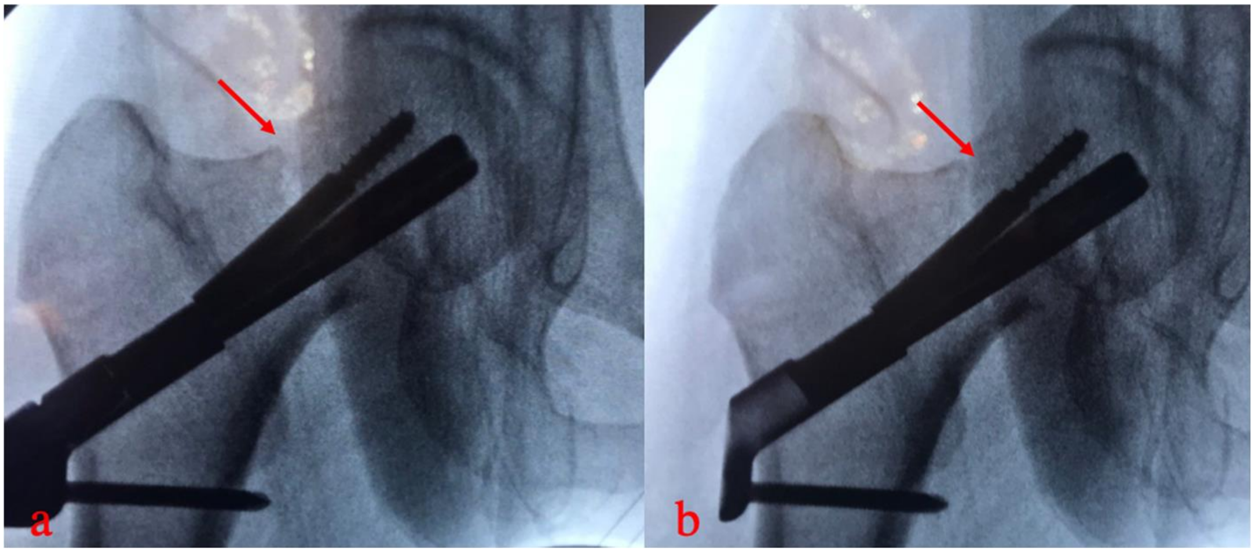

Figure III: FNS can provide a more strong compression fixation of the fracture site

DISCUSSION:

Due to the high-energy trauma mechanisms and displacement fracture patterns commonly observed in this patient population, FNFs in individuals 60 years of age or younger are difficult to treat. Although internal fixation and fracture reduction are currently the most often used therapies for young patients with FNFs, there is still a significant risk of femoral neck shortening, nonunion of fractures, and femoral head necrosis following surgery. Strong and stable internal fixation and anatomical reduction of fractures are essential for preventing the aforementioned issues. The preservation of anatomical reduction is the next logically important requirement for a fixation device in the course of fracture therapy, after it has been established.

The cross-sectional Observational study was conducted in the Department of Orthopedic, National Institute of Traumatology and Orthopedic Rehabilitation (NITOR) from June 2022 to May 2023. A total of 30 subjects of both sexes were included in the study.

In this study, most of the respondents 18 (60.7%) lies between 51 years to 60 years. Mean ± SD of the respondents was 52.41 ± 6.75 years. More than half of the patient 19 (63.30%) were male and 11 (36.70%) patients were female. Most of the patients 17 (56.7%) BMI were in between normal range, 7 (23.3%) were underweight and 6 (20.0%) were overweight. Mean ± SD of the patients BMI was 25.3 ± 5.4 kg/m2. About 12 (40.0%) patients had type III garden fracture, 9 (30.0%) patients had type II garden fracture, and 9 (30.0%) patients had type I garden fracture. Most of the patients 21 (70.0%) had type II Pauwels fracture. The average surgery time was 76.65 ± 34.25 min, the blood loss was 67.45 ± 51.43 ml, the Preoperative Harris Score was 22.25 ± 4.56 and the Postoperative Harris Score was 83.80 ± 5.78, the healing time was 3.33 ± 0.60 and Femoral neck shortens was 2.20 ± 1.41mm. Non-union had occurred in case of 3 (10.0%) patients, Femoral neck shortening had occurred in 2 (6.7%) case and Femoral neck necrosis had occurred in 1 (3.3%) case.

The recently introduced implant FNS (DePuy Synthes, Zuchwil, Switzerland) was developed for the dynamic fixation of FNFs. The FNS includes three parts: an ARS crew, a bolt, and a plate. The plate provides angular stability (a fixed angle between the bolt and the

ARS crew). The cylindrical bolt design was intended to maintain reduction during insertion. The bolt also provided angular stability. The integrated bolt and ARS crew provided rotational stability. Stoffel et al. [5] evaluated the biomechanical performance of FNS in comparison with established methods for fixation of FNFs in a cadaveric model. They concluded that the FNS showed significantly higher overall construct stability compared to CCS in an unstable FNF model, and no significant difference between the FNS and the DHS systems was observed with regard to the most clinically relevant parameters. Schopper et al. [6] evaluated the biomechanical performance of the FNS versus Hansson Pin System (Hansson Pins). The study showed that the FNS can be considered as a valid alternative to the Hansson Pin System for the treatment of Pauwels II FNFs by providing superior resistance against varus deformation and performing in a less sensitive way to variations in implant placement. According to previous studies, we may conclude that the FNS can provide similar effects as DHS, achieve strong and stable fixation, and prevent postoperative hip varus. Based on our experience with intraoperative FNS, FNS can provide a stronger compression fixation of the fracture site. FNS combines the advantages of different existing constructs, such as the minimally invasive insertion technique and retention of more viable bone known for CCS with the increased fracture fixation properties of the DHS system.

Three cannulated screws are used in CCS to press against the fracture and encourage its healing. Furthermore, they impede less with the blood flow to the femoral head and neck and take up a comparatively modest amount of space in the femoral neck.

Triangular distribution can reduce the load of femoral head rotation by forming a three-dimensional skeleton and bone tissue. It can expedite fracture healing, encourage close contact between fracture ends, and increase the compressive stress between fracture ends both during and after surgery. The three cannulated screws, however, do not correlate, and the surgeon's subjective and objective judgments can readily alter the screw position. As a result, it has a low resistance to vertical shear and torsion, which can cause femoral neck shortening, femoral head necrosis and nonunion, and fracture end loosening and displacement [11, 12]. According to a biomechanical study, FNS and DHS had comparable outcomes in terms of femoral neck shortening and fracture repair for parameter cycles to failure [5]. These tools make it possible for the fracture site to collapse under control, which increases the remodeling stimulation. A DHS or FNS provides more mechanical stability to withstand the elevated shear stresses produced in fracture patterns that are dislocated or unstable [5, 13]. The incidence of femoral head necrosis (12.5% vs. 5.0%, $p = 0.389$) and FNF nonunion (12.5% vs. 10.0%, $p = 0.795$) did not differ statistically between the CCS and FNS groups in our investigation.

However, compared to the FNS group, the CCS group experienced a significantly greater incidence of screw cut-out and femoral neck shortening (37.5% vs. 10.0%, $p = 0.036$). According to earlier research, femoral neck shortening in patients with FNFs following CCS treatment may possibly result in hip dysfunction [14, 15]. Weil et al. [16] shown a direct correlation between the incidence of postoperative femoral neck shortening and the quality of FNF reduction. Because FNS has superior mechanical stability and shear resistance, the incidence of femoral neck shortening was considerably lower in the FNS group than in the CCS group in our study. Osteoporosis can lead to a decrease in fixation grip and resistance to stress at the fracture site, resulting in a decrease in stability and a greater likelihood of femoral neck shortening [17, 18]. Additionally, a prior study found that 14.5% of patients experienced cut-out, a typical consequence [19]. The study also suggested that a widely dispersed, nonparallel screw trajectory could prevent the osteoporotic femoral neck from shortening during fracture healing, which could cause the screws to separate from the femoral head [19]. However, none of the patients in the FNS group had screw cutouts because of the locking mechanism of the plate and screw. Both the CCS and FNS groups in this study obtained functionalities that were comparatively satisfactory, and the two groups' postoperative HHSs did not differ statistically significantly. We found that two distinct forms of internal fixation might produce comparable clinical results in terms of the HHS after conducting a meta-analysis to examine the clinical outcomes of two implants (CCS and slide DHS) [20]. The state of the patients, the extent of fracture displacement, the sufficiency of internal fixations, and the caliber of surgical reduction are the main factors influencing the clinical outcome following fixation of FNFs. The FNS group's operation time in our study was longer than the CCS group's, which might have something to do with the surgical tools and skill. Therefore, it is very important to use the FNS skillfully to shorten the operation time. According to the surgeon’s experience, FNS is significantly better than CCS in applying pressure to the fracture site

CONCLUSION:

In conclusion, FNS exhibits noticeably greater overall construct stability and superior biomechanical qualities. FNS therapy can produce satisfactory clinical outcomes for young individuals with FNFs. The likelihood of femoral head necrosis and nonunion following surgery did not significantly change. The FNS group had a noticeably decreased incidence of screw cut-out and femoral neck shortening.

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