Non-parallel screw fixation for femoral neck fractures in young adults

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ABSTRACT

Introduction: Current literature shows divergence of views regarding screws positioning in femoral neck fractures fixation.

The goal of this study is to evaluate the efficiency of divergent screw fixation for fracture neck of femur (NOF).

Methods: The study was conducted at an academic Level 1 Trauma Center.

This is a retrospective study conducted from October 2013 to October 2016.

The study included 41 patients (33 males, 8 females) suffering from fracture NOF who were fixed using BDSF technique (26 within 24 h. & 15 after 24 h.). The average age was 41.5 y (23–49 y). According to Garden classification; 17 patients (41.5%) were type 4, 24 patients (58.5%) were type 3. According to Pauwel's classification; 8 cases (19.5%) were type III, 25 cases (61%) were type II & 8 cases (19.5%) were Type I. Thirty-six cases (88%) were *trans*-cervical, 4 Sub-capital (9.5%) and 1 (2.5%) Basi-cervical. Six patients had comminution at the fracture site.

We evaluated radiographic outcomes of union, femoral neck shortening, screws back-out & femoral head avascular necrosis (AVN). We also evaluated functional outcome using the Harris hip score. Follow-up was 24 months on average (ranging from 20 to 29 months).

Results: One patient was lost during the follow up, the remaining 40 cases gave the following results regarding union: 38 united (within 3–4 months), 2 patients were un-united & one of them developed AVN.

Twenty-seven patients (71%) had femoral neck shortening <5 mm, 8 patients (21%) had shortening 5–10 & 3 patients (8%) had shortening >10 mm. Shortening was on average 3 mm (0–15). Screws back-out distance was on average 4 mm (0 to 16).

Patients with mild femoral neck shortening had Harris hip score of 96 on average (92–100), those with moderate shortening had a score of 75 on average (72–79), those with severe shortening had a score of 62 on average (56–68).

Conclusion: The Authors believes this method provides better union rate & less incidence of femoral neck shortening than that of the conventional inverted triangle screws configuration reported in literature. However multi-center studies & long term follow-up is needed to fully evaluate this method.

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1. Introduction

Femoral neck fractures are a commonly encountered injury in orthopaedic practice and result in significant morbidity and mortality. Use of the Garden and Pauwel's classification systems have remained the practical mainstay of femoral neck fracture characterization that help dictate appropriate treatment. Operative options include in situ fixation, closed vs. open reduction with

internal fixation, and hip arthroplasty. Recent reports demonstrate diversity among orthopaedic surgeons regarding the optimal treatment of femoral neck fractures and changing trends in management.¹

Pauwel's classified femoral neck fractures based on the orientation of the horizontal gradient of the line of fracture. In Pauwels Type 3 fractures, a less compressive load, a high shear stress and varus load are dominant.² The more vertical and lateral the line of fracture is, the more unstable it is. High rates of complications are associated with the internal fixation of such unstable fractures.³

In the current study authors aimed at evaluating the efficiency & Reproducibility of the biplane double supported screw fixation

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(BDSF) method described by Filipov.⁴ We evaluated the rate of union, time to full weight bearing, complications and functional outcome by measuring the Harris hip score. In the original paper follow up was only 8 months on average which the authors thought it's not long enough to fully evaluate such a technique, thus longer follow up was done in the current study.

2. Patients and method

A single-center, retrospective study was conducted at an academic Level 1 Trauma Center. The inclusion and exclusion criteria are enumerated in Table 1. The study was conducted from October 2013 to October 2016. Follow-up was 24 months on average (ranging from 20 to 29 months).

A total of 41 patients (33 males, 8 females) who met the inclusion criteria & did not have any of the exclusion criteria were included in the study. Fracture fixation of all patient was done using the BDSF technique (26 within 24 h. & 15 after 24 h.). The average patients' age was 41.5 years (23–49 years). According to Garden classification; 17 patients (41.5%) were type 4, 24 patients (58.5%) were type 3. According to Pauwel's classification; 8 cases (19.5%) were type III, 25 cases (61%) were type II & 8 cases (19.5%) were Type I. Thirty-six cases (88%) were *trans*-cervical, 4 Sub-capital (9.5%) and 1 (2.5%) *Basi*-cervical. Six patients had comminution at the fracture site.

All patients underwent surgery to fix NOF fracture using the biplane double supported screw fixation (BDSF) described by Filipov⁴ which adopts a divergent screws fixation technique by inserting 3 screws; 2 of these screws are inserted from a metaphyseal entry point aiming at the antero-inferior quadrant of the head and the 3rd screw is inserted from a subtrochanteric (5–7 cm distal from the base of the greater trochanter) entry point aiming at the supero-posterior quadrant of the head & abutting the calcar thus crossing the other 2 screws at an angle in both frontal & sagittal planes, this distal screw orientation provides in addition another point for load transmission to a diaphyseal point on the lateral cortex, it also acts as a vertical beam supporting the head & preventing it from going into varus deformity and decreasing incidence of collapse.⁴

Closed reduction was achieved in all Garden type 3 patients (24 patients), but was not successful in all Garden type 4 patients (17 patients) & open reduction (using antero-lateral Smith-Petersen approach to the hip) had to be done to these patients, where the inter-nervous plane between tensor fasciae latae & the Sartorius is utilized to expose the anterior aspect of the hip capsule which is then incised to directly visualize the femoral neck to achieve anatomic reduction of the fracture; guide pins for the cannulated screws are then inserted through separate stab incisions on the lateral aspect of the thigh to fix the fracture. When reduction is confirmed satisfactory by direct vision of the fracture site & by image intensifier, the screws are advanced over the guide pins for final fracture fixation.

All surgeries were performed by the 1st Author.

Postoperatively patients are discharged the next day after surgery on anticoagulants for 14 days.⁵ The 1st post-operative visit was a wound check after 2 weeks, then follow-up by X-ray is done at monthly intervals till complete union was achieved, then at 6

months' intervals till final follow up. Hip range was encouraged as soon as tolerated by the patient (usually few days after surgery), partial weight bearing was started when tolerated by patients. Full weight bearing was allowed only when full union was achieved.

On follow up visits, 2 blinded observers (the 2 authors) assessed patients for the following outcomes:

1. Radiographically:

- Union, defined as disappearance of fracture line
- Femoral neck shortening, by measuring the distance between the center of the femoral head & the tip of the greater trochanter (which is a representation of the length of abductors muscles lever arm) & comparing it on post-operative radiographs to that at final follow up.
- Backing out of screws.
- Avascular necrosis (AVN), bone scan was done to confirm suspected cases of AVN.

Radiographic assessment was done before the functional assessment to prevent bias.

1 Functionally: assessed according to Harris hip score.⁶

3. Results

One patient was lost during the follow up due to lack of compliance, the remaining 40 cases had the following results; union was achieved in 38 cases (95%) within 3–4 months (Figs. 1 and 2). Two patients failed to unite; the 1st patient (Fig. 3) was a 35 years old male patient (*trans*-cervical, Garden 4, Pauwel's angle 30°) on chronic steroid therapy, he developed infection 1 month postoperatively (surgical debridement was done & the wound became non-draining) then radiographic evidence of AVN appeared 2 months postoperatively & he was scheduled for two stages arthroplasty which was then performed. The 2nd patient was a 38 years old male patient (sub-capital, Garden 3, Pauwel's angle 70°), he was scheduled for arthroplasty which was then performed.

Among the united group (38 patients), we used the method adopted by Zlowodski [7] to evaluate femoral neck shortening & we found that 27 patients (71%) had shortening <5 mm and were considered as non/mild, 8 patients (21%) had shortening 5–10 mm & were considered as moderate (Fig. 4) & 3 patients (8%) had shortening >10 mm & were considered as severe (Fig. 5). The shortening of the femoral neck was on average 3 mm (0–15). The screws backing-out distance was on average 4 mm (0 to 16). The differences between the three groups (none/mild, moderate & severe shortening) for these measurements were statistically significant ($P < 0.001$).

Patients with mild femoral neck shortening had Harris hip score of 96 on average (92–100), those with moderate shortening had a score of 75 on average (72–79), those with severe shortening had a score of 62 on average (56–68).

4. Discussion

The topic of screws configuration, used in fixing neck of femur (NOF) fractures, is still controversial in orthopaedic literature. Most clinicians believe that the inverted triangle configuration using 3 cannulated screws provides superior biomechanical stability & hence good clinical results.⁸

Based on the study conducted by Xia.X. and Liu.Z, non-parallel screws technique allows the screws to share more weight thus reducing postoperative complications (such as femoral neck

Table 1
inclusion and exclusion criteria.

Inclusion Criteria	Exclusion Criteria
Neck of Femur Fracture (NOF)	Concomitant Ipsilateral femoral shaft fractures
20–50 years old	Pathological fractures
Closed fractures	Stress fractures

Fig. 1. United Case Example No.1, **A:** Preoperative AP view; **B:** Post-operative **C:** Last follow.

Fig. 2. United Case Example No.2, **A:** Preoperative AP view; **B:** Post-operative **C:** Last follow.

shortening) and may be more suitable for elderly patients.⁸ Recent studies describing different techniques for divergent screws fixation of neck of femur fractures showed promising results.^{4,9}

BDSF technique is designed to insert oblique screw to improve the internal fixation strength of intra-capsular femoral neck fractures, theoretically based on the concept of the establishment of two supporting points for the implants used; those 2 points are the sub-trochanteric point at the lower screw as well as the metaphyseal point of the upper 2 screws. The screws are crossing which provide bi-planar stability.⁴

Filipov O. applied the technique on 88 patients, the average age was 76.9 (with the youngest patient aged 38 and the oldest aged 99), and the average follow-up period is 8.06 months. The fractures have been classified by the Garden classification as follows: Garden type I: 3 (3.41%); Garden type II: 1 (1.14%); Garden type III: 9 (10.23%); Garden type IV: 75 (85.02%). Out of the studied 88

patients, union was achieved in 87 patients (98.86%) and non-union in 1 patient (1.13%).⁴

A comparison between our results & that of Filipov O. study⁴ is shown in Table 2.

A meta-analysis study by Lu-Yao¹⁰ that included 106 reports (that used the inverted triangle screws configuration) for the treatment of displaced fractures of the femoral neck, showed that non-union had developed in 33% of patients and avascular necrosis (AVN) in 16% of patients 2 years or less after primary internal fixation of a displaced fracture of the femoral neck. The study also demonstrated that the incidence of complications experienced by young femoral neck fracture patients is relatively high & re-operation following internal fixation of isolated femoral neck fractures occurred in nearly 20% of cases. AVN and nonunion were the most common complications that likely contributed to repeat surgeries [7].

Fig. 3. AVN Case Example, **A:** Preoperative AP view; **B:** Post-operative **C:** Last follow.

Fig. 4. Moderate shortening of the femoral neck Case Example, **A:** Preoperative AP view; **B:** Post-operative **C:** Last follow.

Fig. 5. Severe shortening of the femoral neck Case Example, **A:** Preoperative AP view; **B:** Post-operative **C:** Last follow.

Table 2

Comparison between our study and Filipov O. study.

	Our study	Filipov O. study
Number of patients	41	88
Sex	Male 33, Female 8	Male 27, Female 61
Average Age	41.5 years old	76.9 years old
Average follow up	24 months	8 months
Garden classification	I 0	I 3
	II 0	II 1
	III 24	III 9
	IV 17	IV 75
Mean operative time	45 min	39 min
Union rate	United 95%	United 98.86%
	Un-united 5%	Un-united 1.13%

Our study using non-parallel screws shows better results as regard union rate & incidence of AVN.

Weil, Y. A.¹¹ assessed femoral neck shortening (FNS) after internal fixation of femoral neck fractures in 41 patients fixed with 3 cannulated screws in inverted triangle configuration. He found that femoral neck shortening (greater than 5 mm) occurred in 56% of the patients & severe shortening (greater than 10 mm) in 22% of patients. Screw backing out (greater than 5 mm) occurred in 17 (41%) patients. Seven patients required late (more than 6 months after primary internal fixation) arthroplasty. Femoral neck shortening did not significantly correlate with fracture type, quality of reduction, age, or neck shaft angle. In the study done by Zlowodzki⁸ who assessed patients' function based on the amount of femoral neck shortening, he reported shortening < 5 mm only in 34% of patients & showed that the functional outcome was significantly affected by neck shortening & it correlated with the amount of shortening & concluded that a shortening of <5 mm would have better functional outcome when compared to those who has shortening >5 mm.

Our study shows less incidence of femoral neck shortening.

In Conclusion, the Authors believe this method is easily reproducible with similar results & also believe it appears to lower the incidence of femoral neck shortening which is known to have a negative impact on the functional outcomes after NOF fracture fixation. However multi-center studies & long term follow-up is needed to fully evaluate this method

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Conflict of interest

The authors have none to declare.

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent

Informed consent was obtained from all individual participants included in the study.

Level of evidence

Level III, Therapeutic study.

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