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Original Article

Outcomes of BDSF technique for osteosynthesis of femoral neck fractures

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Abstract: Introduction: Femoral neck fractures present a significant challenge for orthopedic surgeons, especially in young patients who want to preserve their natural femoral head. Conventional methods for fixing these fractures often lead to poor outcomes and high complication rates. The Biplane Double-supported Screw Fixation (BDSF) technique is a novel approach that involves placing screws in two planes simultaneously, creating a two-point support for the screws in the neck and head of the femur. Methods: This study aimed to evaluate the effectiveness of the BDSF technique in treating femoral neck fractures in patients aged 20-60 years. A total of 28 patients with fresh femoral neck fractures (less than three weeks old) were treated with closed reduction and internal fixation using the BDSF method. The patients' functional outcomes were evaluated using the Harris hip score, and the radiographic outcomes of union, femoral neck shortening, screw back-out, and femoral head avascular necrosis (AVN) were also evaluated. Results: The results showed that the BDSF technique is a safe and effective method for treating femoral neck fractures in young adults. Out of the 25 patients who were followed up for a mean time of 18 months (range 6-24 months), 20 (80%) achieved fracture union in a mean time of 5.2 months. Non-union occurred in five patients (20%), and AVN of the femoral head was observed in three patients (12%). Two patients experienced varus collapse, but their fractures united successfully. Conclusion: The BDSF technique offers several advantages over conventional methods, including increased stability and improved fixation strength. It can be considered as an alternative to conventional methods for managing femoral neck fractures in young adults, with a low incidence of non-union and avascular necrosis and no cases of fixation failure or varus collapse.

Keywords: BDSF, neck femur, fixation, osteosynthesis, non union, avascular necrosis

Introduction

A fracture of the neck of the femur (NOF) is a challenging injury to treat, as it has a high incidence of avascular necrosis of the femoral head and a significant risk of non-union, particularly in younger patients who desire to preserve their natural femoral head [1]. Women have a lifetime risk of hip fracture that ranges from 40% to 50%, whereas men have a risk of 13% to 22% [2]. The burden of hip fractures is expected to reach 6.26 million by 2050 [2, 3]. The current conventional inverted triangle method for NOF fracture fixation is associated with poor outcomes in 20-42% of cases, owing to various biomechanical issues [4-6]. As a result, the complication rates are high.

A new technique for screw fixation in femoral neck fractures, known as the Biplane Double-supported Screw Fixation (BDSF) method, was developed by O. Filipov [6, 7]. This method involves placing the screws in two planes simultaneously, creating a two-point support for the screws in the neck and head of the femur. This approach is necessary to support the weight-bearing head of the femur, which acts as a beam with an overhanging end. By placing the screws in a biplane fashion, the entry point can be more distally placed into the solid diaphyseal cortex, allowing the distal screw to be placed along the calcar femorale, resulting in two-point fixation. This positioning allows for the whole construct to act as a simple beam, transferring the weight to the femoral diaphysis, and improving fixation strength compared to conventional parallel screw fixation.

BDSF offers several advantages over conventional techniques. First, two screws support the

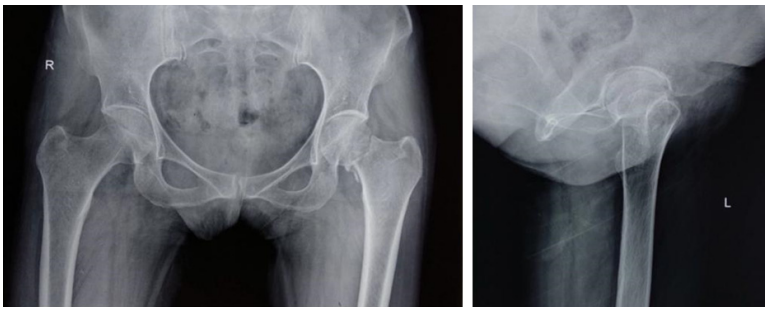

Figure 1. Pre-op X-ray, AP and lateral view of Case 1.

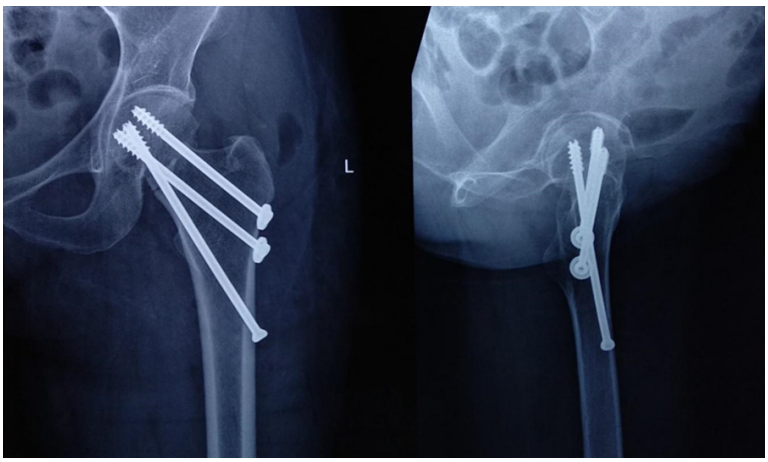

Figure 2. Immediate post-op X-ray of the patient.

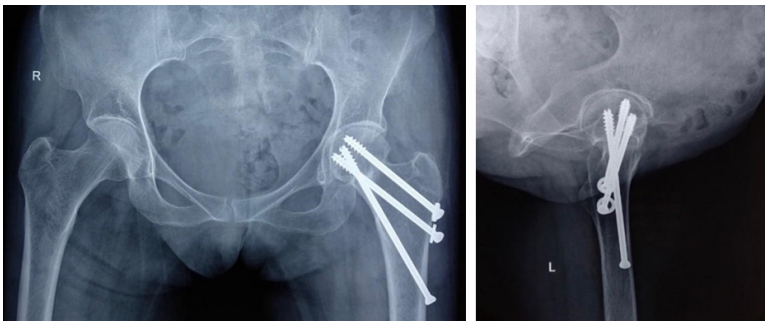

Figure 3. United fracture at the last follow-up.

calcar in BDSF, compared to only one in conventional methods. Additionally, the screws are spread over a larger area in BDSF, distributing the axial load from the head to the diaphysis and reducing the risk of varus collapse and screw cut out. The steeper angle of the screws in BDSF also allows for impaction at the fracture site during weight-bearing, decreasing the risk of subtrochanteric fractures. The stability of the fixation is increased with BDSF, making it useful in comminuted and Pauwel's type III fractures where conventional fixation might fail. Furthermore, the placement of screws in BDSF is away from the weight-bearing pole of the head of femur, reducing the risk of damage to the intraosseous blood supply.

In summary, BDSF is a new technique for screw fixation in femoral neck fractures that offers advantages over conventional techniques. By creating a two-point support and biplane positioning of screws, it improves the stability of the fracture neck femur and can enhance constant stability during various patient activities.

The objective of this research was to assess the effectiveness of the BDSF technique in managing femoral neck fractures in individuals aged 20-60 years old. The study aimed to examine the incidence of fixation failure, nonunion, avascular necrosis of the femoral head, varus collapse, and other complications associated with this technique. Historically, femoral neck fracture management has been challenging as no single fixation method has been universally successful. Additionally, there is a paucity of literature on the BDSF technique. Hence, this study seeks to evaluate the efficacy of this novel osteosynthesis approach for femoral neck fractures in young adults.

Material and methods

This study was conducted at the Department of Orthopedic Surgery between November 2017 and November 2019. The study included all skeletally mature patients presenting to outpatient department and emergency with acute (< 21 days old) fracture neck of femur (both undisplaced and displaced) (**Figures 1**, **4**). Patients with fractures > 21 days old, concomitant ipsilateral femoral shaft fracture, pathological fracture, or stress fracture were exclud-

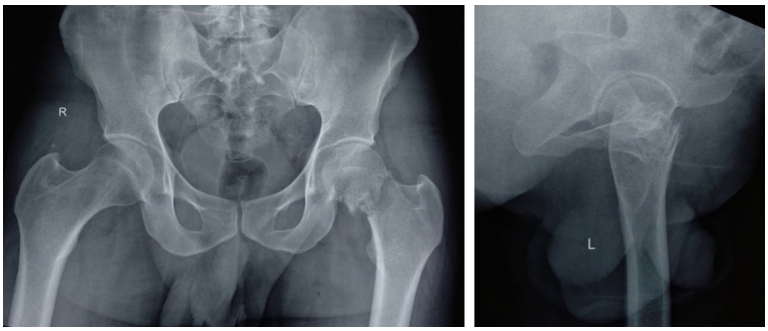

Figure 4. Pre-op X-ray, AP and lateral view of Case 2.

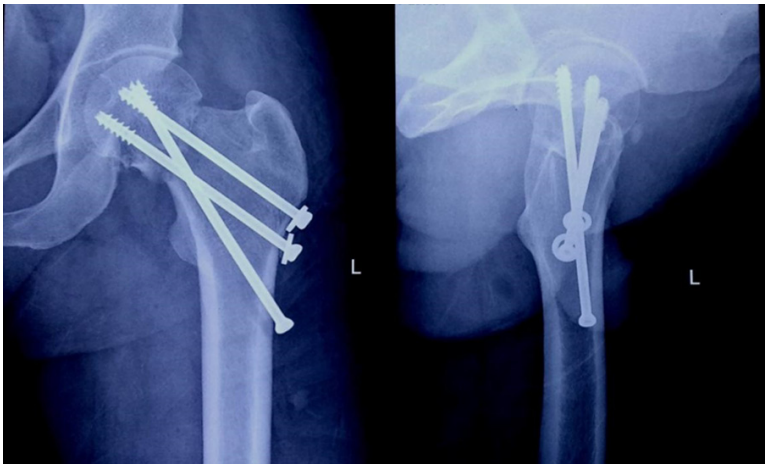

Figure 5. Immediate post-op X-ray of the patient.

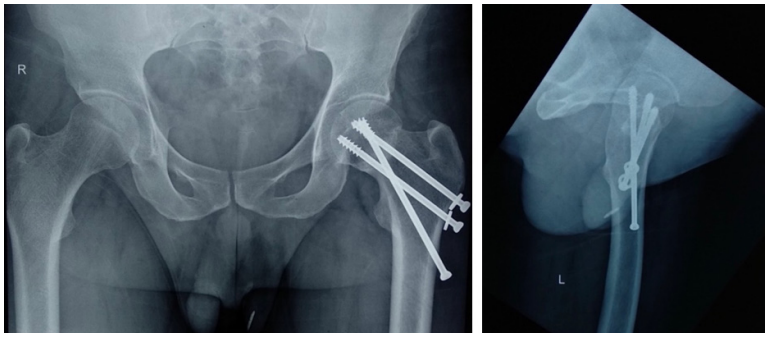

Figure 6. X-ray of the patient showing union, neck shortening and screw back out.

ed from the study. All the included patients were treated with closed reduction and internal fixation using the BDSF method. This study was approved by the ethics committee (1014/FM/14/03/2018).

The fracture reduction was performed using the Whitman technique under spinal anaesthesia, and the reduction was assessed using the garden alignment index. The acceptability of reduction was confirmed using AP and lateral views with the help of a C-arm. The fracture was fixed using the BDSF technique (**Figures 2**, **5**), which involves creating a two-point support for the screws and placing them simultaneously in two planes in the neck and head of the femur [7]. Postoperatively, intravenous antibiotics were given for 48 hours, and range of motion exercises of the hip and knee were initiated on the second post-operative day, starting with passive exercises and progressing to active exercises as tolerated by the patient without discomfort. Partial weight bearing walk or toe touch walk was started after 6-8 weeks, and full weight bearing walk was started after radiological fracture union (**Figures 3**, **6**).

The patients were evaluated clinically and radiologically before surgery and at 6-week intervals after surgery until fracture union was achieved, followed by 2-month intervals. The data were analyzed using proportions, mean, and standard deviations. Union was defined as the presence of bridging trabeculae at the fracture site and the ability of the patient to bear weight on the affected hip. Non-union was defined as the absence of progressive signs of union, such as bridging trabeculae at the fracture site, or the presence of a gap at the fracture site after 6 months. Shortening of the femoral neck was estimated by measuring the distance between the center of the femoral head and the tip of the greater trochanter and comparing the difference between post-operative radiographs and final follow-up [9, 10]. Varus collapse was calculated by measuring the neck shaft angle of the operated side at the final follow-up and compar-

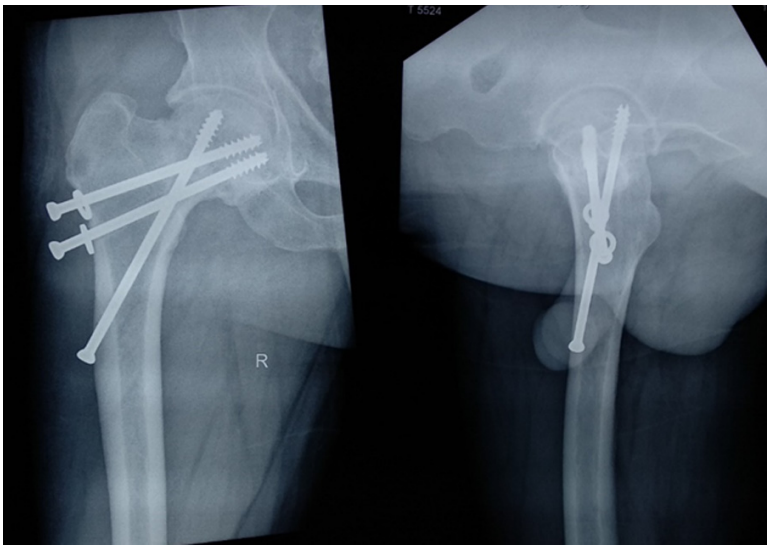

Figure 7. United fracture with varus collapse, neck shortening and screw back out (Case 3).

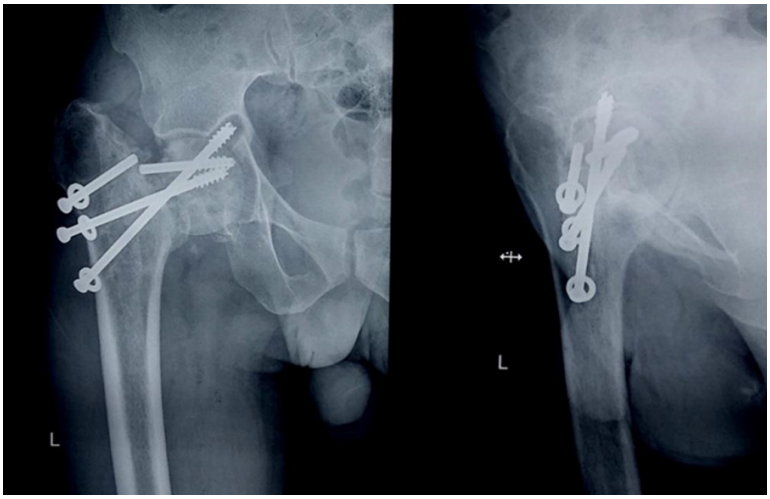

Figure 8. Non-union, AVN with screw breakage and cut out (Case 4).

Figure 9. United fracture with AVN of head of femur (Case 5).

ing it to the normal side [9, 10]. Backing out of screws was calculated by measuring the length of the screw protruding out from the lateral femoral cortex. Avascular necrosis of the femoral head was suspected when sclerosis, subchondral cysts, or collapse of the femoral head were present.

Regular follow-up was done in the OPD at 6-week intervals until union, followed by 2-month intervals. Clinical assessment was done using the Harris Hip Score. Any shortening, collapse, backing out of screws, or avascular necrosis of the femoral head were considered significant if they exceeded certain thresholds. All X-rays were taken with controlled magnification and in 20° abduction and 15° internal rotation. Statistical analysis of recorded data was analyzed using Excel Software (Microsoft, Redmond, USA). Mean, ranges and proportions were calculated using Excel software to analyze the results of the cohort.

Results

This research involved 28 patients, but 3 of them were lost to follow-up, so the results of 25 patients were presented. The mean age of the patients was 39.9 years, ranging from 20 to 58 years, and 48% of them were male while 52% were female. The majority of the patients had Garden type III (56%) and Pauwel's type II (68%) fractures. The average time between injury and surgery was 6.9 days, ranging from 2 to 20 days. Out of the 25 patients followed up, 20 of them (80%) achieved union, and the mean time to union was 5.2 months. The remaining 20% of patients suffered from non-union, while 12% developed AVN (**Figure 8**). Among the 20 cases that achieved union, 2 (10%) developed significant varus collapse (> 5°) (**Figure 7**), and the mean difference in the

Table 1. Comparison between our study and study by other authors

	Our study	Filipov et al.	Galal et al.
No. of patients	25	88	41
Sex	12 Males	27 Males	33 Males
	13 Females	61 Females	8 Females
Mean age	39.9 years	76.9 years	41.5 years
Mean follow up	13 months	8 months	24 months
Garden's type	I 0	I 3	I 0
	II 1	II 1	II 0
	III 14	III 9	III 24
	IV 10	IV 75	IV 17
Union rate	80%	98.86%	95%

neck shaft angle was 4.8°, with collapse ranging from 3° to 10°. A total of 60% of patients had significant neck shortening (> 5 mm), with the mean femoral neck shortening being 7.4 mm and ranging from 4 mm to 12 mm. Four patients (20%) had significant screw backout (> 5 mm) (**Figure 7**). Most of the patients had a good functional outcome, with 5 patients (20%) having a poor Harris hip score, 2 patients (8%) having a fair score, 13 patients (52%) having a good score, and 5 patients (20%) having an excellent score. Five patients had their screws removed, while two patients underwent total hip arthroplasty due to non-union and screw cut out, and one patient underwent hemiarthroplasty due to non-union, while the other two only had their screws removed due to AVN and non-union (**Figures 8**, **9**).

Discussion

The optimal method for treating femoral neck fractures remains a topic of debate in current literature. Despite the use of multiple cannulated cancellous screws in an inverted triangle configuration, results have been unsatisfactory with complications ranging from 20-42% [4-6]. Several factors have been identified as the cause of the high failure rate associated with conventional screw fixation. For instance, to resist shearing forces, screws must be firmly anchored in at least two points in the distal fragment. However, the entry sites of the three screws used in conventional screw fixation techniques do not meet this requirement as they are positioned at or near the thin cortex of the greater trochanter. Additionally, intraoperative compression required for fixation is dependent on the cancellous bone's strength. However, the orientation of screws is less vertical in conventional techniques than in BDSF, resulting in less impaction at the fracture site.

Recent studies describing BDSF procedures for neck femur fractures have produced promising outcomes. For example, Filipov et al. evaluated 88 patients, 87 of whom (98.86%) achieved fracture union, and only one (1.13%) experienced non-union [7]. Similarly, Galal et al. assessed 41 patients, 38 of whom (95%) achieved fracture union, with two (5%) cases of failure [8]. In our study, which included 25 patients, the rate of union was 80%, while non-union and AVN rates were 20% and 12%, respectively (**Table 1**). Available data suggests that neck femur fixation in young patients results in a union rate of 70% with a complication rate of around 30% [9-11].

In a meta-analysis conducted by Slobogean GP et al., it was found that the non-union rate for displaced fractures in patients under 60 years of age was 10%, while the non-union rate for undisplaced fractures was 5% [12]. The meta-analysis also reported a failure of fixation in 9.7% of cases. Another recent meta-analysis by Damany et al. estimated the average non-union rate to be 8.9% following fixation in patients with young hip fractures, with an avascular necrosis (AVN) rate of 23% [13]. Barnes et al., in their multicenter study involving 1,503 femoral neck fractures, found that the union rates for nondisplaced fractures were not related to the grade of fracture [16]. The union rates in our study were not as good as those shown in the studies on the biplane double-supported screw fixation (BDSF) method by Filipov and Galal et al. Wang et al. found that higher grades of Pauwel's classification resulted in higher rates of non-union and AVN in their study of femoral neck fractures in young adults, which was also observed in our study where the union rates were lower for Pauwel's type III fractures [14]. In our study, the mean Harris hip score was 75.2, and 72% of patients had excellent to good functional outcomes.

Screw back out was present in most of our patients, and significant screw back out (> 5 mm) was observed in 20% of patients with united fractures. In previous studies, the mean screw back out was found to be 4 mm in the BDSF method, and 41% in the conventional

technique. Backing out of screws could have occurred due to poor bone quality. Out of 20 united fractures, 10% developed significant varus collapse, and 60% developed significant neck shortening. The rate of varus collapse in our study was comparable to that observed in the conventional technique, and femoral neck shortening was similar to that reported in other studies [15, 16].

Three patients in our study developed AVN of the head of femur, all of whom were Garden type IV. In previous studies, the failure of fixation and non-union rate were found to be 33% and 16%, respectively, with conventional fixation techniques. The total non-union rates and AVN rates in displaced fractures were estimated to be 9.3% and 14.7%, respectively, in the largest systematic review by Slobogean GP et al. Barnes et al. found that 24% of women and 15% of men experienced AVN in 1,500 neck femur fractures fixed with the conventional technique, with a lower incidence in undisplaced fractures (16%) than displaced fractures (27.6%). In our study, the non-union rate was 20%, and the rate of AVN was 12%, which was comparable to previous studies. The rate of AVN was higher in displaced and Pauwel's type III fractures.

None of our patients experienced subtrochanteric fractures after surgery, despite the most distal screw being positioned below the lesser trochanter. Filipov concluded that the tensile forces that act on the lateral cortex spread over a broader area, minimizing the likelihood of subtrochanteric fracture in his biomechanical study of the BDSF method.

Conclusion

Femoral neck fractures among young individuals are a significant contributor to the socioeconomic burden of our country. To ensure successful bone healing in displaced fractures, it is crucial to perform an anatomical reduction and rigid internal fixation. However, there is a lack of consensus in the literature regarding the most appropriate treatment method. In our study, we utilized the BDSF technique developed by O. Filipov et al. While our results did not match the excellent outcomes reported by Filipov and Galal et al., we did find that our results were comparable to studies utilizing conventional screw fixation. Therefore, BDSF may serve as a viable alternative for femoral neck fractures. However, our study was limited by its small sample size and lack of comparative analysis. Thus, further multicentre studies are needed to fully evaluate the efficacy of this method.

Disclosure of conflict of interest

None.

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References

[1] Pauyo T, Drager J, Albers A and Harvey EJ. Management of femoral neck fractures in the young patient: a critical analysis review. World J Orthop 2014; 5: 204-17.

[2] Liddicoat M. National Hip Fracture Data Base (NHFD), 2017. https://www.researchgate.net/publication/329673879_National_Hip_Fracture_Data_Base_NHFD_2017_annual_report.

[3] Gjertsen JE, Vinje T, Engesaeter LB, Lie SA, Havelin LI, Furnes O and Fevang JM. Internal screw fixation compared with bipolar hemiarthroplasty for treatment of displaced femoral neck fractures in elderly patients. J Bone Joint Surg Am 2010; 92: 619-28.

[4] Tidermark J, Ponzer S, Svensson O, Soderqvist A and Tornkvist H. Internal fixation compared with total hip replacement for displaced femoral neck fractures in the elderly. A randomised, controlled trial. J Bone Joint Surg Br 2003; 85: 380-8.

[5] Lu-Yao GL, Keller RB, Littenberg B and Wennberg JE. Outcomes after displaced fractures of the femoral neck. A meta-analysis of one hundred and six published reports. J Bone Joint Surg Am 1994; 76: 15-25.

[6] Filipov O. Biplane double-supported screw fixation (F-technique): a method of screw fixation at osteoporotic fractures of the femoral neck. Eur J Orthop Surg Traumatol 2011; 21: 539-43.

[7] Galal S and Nagy M. Non-parallel screw fixation for femoral neck fractures in young adults. J Clin Orthop Trauma 2017; 8: 220-4.

[8] Weil YA, Khoury A, Zuaiter I, Safran O, Liebergall M and Mosheiff R. Femoral neck shortening and varus collapse after navigated fixation of intracapsular femoral neck fractures. J Orthop Trauma 2012; 26: 19-23.

[9] Kofoed H. Femoral neck fractures in young adults. Injury 1982; 14: 146-50.

[10] Haidukewych GJ, Rothwell WS, Jacofsky DJ, Torchia ME and Berry DJ. Operative treatment of femoral neck fractures in patients between the ages of fifteen and fifty years. J Bone Joint Surg Am 2004; 86: 1711-6.
[11] Slobogean GP, Sprague SA, Scott T and Bhandari M. Complications following young femoral neck fractures. Injury 2015; 46: 484-91.
[12] Damany DS, Parker MJ and Chojnowski A. Complications after intracapsular hip fractures in young adults. A meta-analysis of 18 published studies involving 564 fractures. Injury 2005; 36: 131-41.
[13] Barnes R, Brown JT, Garden RS and Nicoll EA. Subcapital fractures of the femur. A prospective review. J Bone Joint Surg Br 1976; 58: 2-24.
[14] Wang SH, Yang JJ, Shen HC, Lin LC, Lee MS and Pan RY. Using a modified Pauwels method to predict the outcome of femoral neck fracture in relatively young patients. Injury 2015; 46: 1969-74.
[15] Zlowodzki M, Brink O, Switzer J, Wingerter S, Woodall J Jr, Petrisor BA, Kregor PJ, Bruinsma DR and Bhandari M. The effect of shortening and varus collapse of the femoral neck on function after fixation of intracapsular fracture of the hip: a multi-centre cohort study. J Bone Joint Surg Br 2008; 90: 1487-94.
[16] Robinson CM, Court-Brown CM, McQueen MM and Christie J. Hip fractures in adults younger than 50 years of age. Epidemiology and results. Clin Orthop Relat Res 1995; 238-46.