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Research Article

Outcome of Screw Fixation for Stable Femoral Neck Fractures in Old Population

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Abstract

Introduction: Selection of an appropriate modality of treatment is an essential step in management of stable femoral neck fractures. While dealing with a femoral neck fracture, there is often an opinion to go for operative management. In this study we evaluate the efficacy and safety of cancellous screw fixation in the older population, alongside comparing the post-operative outcomes and complications of three parallel versus inverted triangle configuration of screws.

Materials and Methods: This is a retrospective observational study of older patients with stable femoral neck fracture who underwent fixation with cancellous screws between January 2016 to January 2021. Data was analyzed using statistical tools.

Results: A total of twenty-seven patients were included in the study and fixed with cancellous screw, 12 (44.4%) underwent fixation with three parallel screws whereas 15 (55.6%) were fixed with inverted triangle configuration. All patients achieved union, functional outcome at 24 months using Harris hip score was excellent in 12 (44.4%) patients, good in 5(18.5%), fair in 8 (29.6%) and 2 (7.4%) had poor outcome. Three (11.1%) patients had post-operative complications, one had hip arthritis and 2 (7.4%) developed Avascular Necrosis (AVN) of the femoral head. Significant (p=0.04) correlation was found between three parallel screw fixation and post-operative complications.

Conclusions: Although all patients achieved union in our study, three parallel screw pattern showed significant increase in post-operative complication rate. The inverted triangle pattern showed a more stable construct with less femoral neck shortening and less rate of AVN, without significant correlation.

Keywords: Femoral Neck; Stable Fracture; Cancellous Screw; Elderly; AVN; Union

Abbreviations

AVN: Avascular Necrosis; OTA/AO: Orthopedic Trauma Association/Arbeitsgemeinschaft für Osteosynthesefragen; BMI: Body Mass Index; BMD: Bone Mineral Density; SD: Standard Deviation; VAS: Visual Analogue score; HHS: Harris Hip Score; AAOS: American Academy of Orthopedic Surgeons; THR: Total Hip Replacement

Introduction

Fractures of the neck of femur are a significant public health issue. These fractures are considered low energy injury and occur mainly in older adults. It could be broadly classified into stable (undisplaced) and unstable (displaced) fractures. The stable neck of femur fractures does not have significant displacement and angulation, yet if not treated appropriately are associated with high rates of morbidity and mortality [1]. Neck of femur fractures are classified and graded commonly based on Garden's grading system on an Anteroposterior view of the hip joint [2]. Garden 1 fractures are classified as incomplete or valgus impacted ones, whereas Garden 2 fractures are complete nondisplaced fractures of femoral neck. These fractures need appropriate management to attain good functional outcomes and reduce complication rates [3].

Current management of undisplaced neck of femur fracture include options of non-operative and operative management [4-14]. Among the cancellous screws fixation, various configuration

of screws have been described including two screws, three screws (parallel, triangle, inverted triangle, Biplane double-supported screw fixation design) and four screws (quadrangular/diamond,) [15-19]. Cancellous screws are considered a less invasive alternative to other internal fixation methods and hip arthroplasty, resulting in lesser operative time, blood loss and morbidity alongside possibly offering better preservation of femoral head blood supply [20].

The purpose of this study is to evaluate the efficacy and safety of cancellous screws fixation in the management of undisplaced neck of femur fractures in older population. In this study we have fixed the fractures by three cancellous screws in parallel (Figure 1) or inverted triangle (Figure 2) pattern and have compared the functional outcomes, complications, and the rate of revision surgery to find out the better design.

Material and Method

Institutional review board approval was obtained IRB# 22-562. STROBE guidelines were followed for this study. This retrospective observational study was done by collecting data from a level 1 trauma center and associated tertiary hospital in 5 years from January 2016 to January 2021. Patients with neck of femur fracture which met the inclusion criteria were included in this study. The inclusion criteria were - patients whose age at time of injury was more than 60 years old, had femoral neck fractures which were stable, their femoral neck fractures corresponded to an Orthopedic Trauma Association/AO (Arbeitsgemeinschaft für Osteosynthesefragen) Foundation (OTA/AO) classification of 31-B1.1, 31-B1.2 or 31-B2.1 (Sub capital and transcervical fractures) and those patients who were fit to undergo surgical procedure. The exclusion criteria for the study were polytrauma cases, patients with ipsilateral femur shaft fracture, patients with head injuries, cases with pathological or stress fractures secondary to tumors and not including osteoporosis, arthritic changes in hip joint, patients with incomplete medical records or follow up of less than 24 months.

All surgical procedures were performed in the tertiary hospital, with patients in supine position on fracture table and partially threaded cancellous cannulated screws 6.5mm were used. Postoperative physiotherapy included active assisted range of motion exercises of hip and knee, sitting, quadriceps strengthening exercises and wheelchair ambulation. Sutures were removed after two weeks, partial weight bearing was allowed at 3 weeks, followed by full weight bearing at 6 weeks post operatively guided by stability of fixation and progress of healing as shown on radiographs.

X rays were reviewed at follow up at 2 and 6 weeks and 3, 6, 12 and 24months. Immediate post operative (op) X rays were used in evaluation of Valgus angle and posterior tilt. The valgus angle was measured by locating the femoral head center and the deepest point of the fovea centralis, which is a conspicuous and consistent anatomic landmark on the femoral head. Then the angle formed by the line connecting the deepest point of the fovea centralis and the center of the femoral head and the longitudinal axis of the femoral shaft on the unaffected side was measured (β). In the same way, the angle of the affected side was measured (α). The valgus angle was defined as the difference between these two angles (α-β) [12]. The posterior tilt angle was assessed using Palm's method, measured as the angle between the mid-column line and the radius column line, which is drawn from the center of the caput circle to the crossing of the caput circle and the mid-column line [21].

Follow up post op X rays were taken to assess radiological union, calculation of proximal femoral vertical shortening and impaction (backward displacement/sliding of screws) of neck of femur. Vertical shortening was measured by comparison of pre op and post op images by looking at proximal migration of tip of greater trochanter according to Zhang., *et al.* [22]. Increase in impaction of neck of femur was calculated by analysis of displacement or recoil of cancellous screws according to Felton., *et al*. [23]. All patients had a radiological follow up of at least 24 months, and assessment of radiographs was done by two authors individually on standard scale to overcome the observational bias.

After 24 months of the surgery, a functional assessment was performed using Harris hip score. Failure of internal fixation was defined as >1 cm displacement of fracture site, penetration of screws through the femoral head into the hip joint, more than 2cm of backward displacement of screws according to Kim., *et al.* [24]. Furthermore failure of fixation was also defined as a new onset of pain due to new arthritic changes in hip joint, biological nonunion (causing persistent hip pain) with radiological nonunion or presence of avascular necrosis of femoral head. In such cases the patient was counselled, and subsequently total hip replacement was advised. Complications as development of hip pain, (Avascular necrosis) AVN and nonunion of the fracture were noted.

Data were analyzed using SPSS software v.25 (version 25.0 for Windows; IBM, Armonk, NY). Descriptive Statistics was used to calculate the frequencies percentages, mean and standard deviations. Chi-square analysis was used to assess the significant differences across categorical data and Mann-whitney tests were used to compute the significant differences across the continuous data. All the tests were two tailed and a p-value less than 0.05 was considered significant.

Results

Twenty-seven patients who met the inclusion criteria were included in the study. Of these 8 (29.6%) were male and 19 (70.4%) were female. The mean age of patients in the study was 68.81 ± 8.171 with a range of 60-84 years. Fractures of left hip occurred in 19 patients (704%), while 8 patients (29.6%) had right hip fractures. There were 20 (74.1%) cases of garden type I and 7 (25.9%) cases of garden type II, of which 12 (44.4%) were subcapital and 15(55.6%) were transcervical.

In the study, 3 (11.1%) patients had normal bone mineral density, 12 (44.4%) had osteopenia and 12 (44.4%) patients were found to have osteoporosis, this information was derived by analysis of patients' medical records where BMD was studied before the incidence of fractures. The same applies to data about BMI, got from the electronic records that showed two cases (7.4%) were underweight, 12 cases (44.4%) were normal, 11 cases (40.7%) were overweight, and 2 cases (7.4%) were obese. The average BMI of the study group was 25.58 ± 4.5 with a range between 16.82 to 35.59. The average follow up of patients for this study was 34.1 months (26-61 months). Fixation of neck of femur was done using 3 cancellous cannulated screws in two different configurations. Parallel screws were used for 12 (44.4%) patients and inverted triangle in 15 (55.6%) patients. The average time of radiological union was 1-3 months with a mean of 2.07± 0.68 months. The average hospitalization time was 5.81 ± 2.08 days with a range of 3-11 days. Demographic characteristics of the patients are presented in table 1.

	Total n = 27
Age, mean ± SD (min-max)	68.81 ± 8.17 (60-84)
Gender, n (%)	
Female	19 (70.4%)
Male	8 (29.6%)
Side of fracture n (%)	
Right	8 (29.6 %)
Left	19 (70.4 %)
BMD, n (%)	
Normal	3 (11.1 %)
Osteopenia	12 (44.4%)
Osteoporosis	12 (44.4%)
BMI, mean±SD (min-max)	25.58 ± 4.50 (16.8-35.6)
BMI, n (%)	
Underweight	2 (7.4%)
Normal	12(44.4%)
Overweight	11 (40.7%)
Obese	2 (7.4%)
Gardens classification	
Type 1	20 (74.1%)
Type 2	7 (25.9%)
Level of fracture	
Subcapital	12 (44.4 %)
Transcervical	15 (55.6 %)
Fixation Configuration	
Parallel design	12(44.4%)
Inverted triangle design	15(55.6%)
Timing of surgery since the fracture, n (%)	
<24 hours	12 (44.4%)
24-48 hours	12 (44.4%)
>48 hours	3 (11.1%)

Table 1: Demographic data of patients.

Twelve (44.4%) patients were operated within 24 hours of injury, and 12 (44.4%) were operated between 24-48 hours, however 3 (11.1%) were operated after 48 hours of injury. In this study, 17 (63%) patients maintained their preinjury pattern of walking and weight bearing while 10 patients showed changes in form of a shift to a higher level of support for walking. Patients were categorized into the following categories based on walking status from not using any walking aid, using stick, walking frame or nearly bedridden.

Radiological analysis showed an immediate post op valgus angle of 7.7 ± 4.286 degrees (0-18 degrees) and posterior tilt angle of 5.41 ± 5.071 degrees (0-22 degrees) as compared to normal non operated side. Twenty-four months' post-operative x ray was compared to immediate postoperative x ray where an impaction of 2.96 ± 2.139 mm (0-8mm) and a proximal femur shortening of 1.41 ± 1.986 mm (0-7mm) was detected.

Functional assessment of the patients using Harris hip score was performed 24 months after treatment. Twelve (44.4%) patients had excellent outcome, 5 (18.5%) had good, 8 (29.6%) had fair and 2 (7.4%) patients had poor outcome. The mean Harris hip score for all the patients was 85.463 ± 12.481 (range of 52.9 - 99.5). The mean VAS score for the group at 24 months following surgery was 0.74 with a range of 0-4. Comparative data with statistical analysis of inverted triangle and parallel screw configuration is presented in table 2.

Three (11.1%) patients in this study were found to have complications after surgery. One patient developed arthritic changes

	Parallel 3 (n = 12)	Inverted Triangle (n = 15)	Total (n = 27)	p-value
Grade of HHS, n (%)				0.235
Poor	2 (16.7)	0	2 (7.4)	
Fair	2 (16.7)	6 (40.0)	8 (29.6)	
Good	3 (25.0)	2 (13.3)	5 (18.5)	
Excellent	5 (41.7)	7 (46.7)	12 (44.4)	
Shortening on X-ray [E], mean ± SD (min-max)	1.44 ± 1.60 (0-4)	0.81 ± 1.47 (0-4)	1.04 ± 1.51 (0-4)	0.464
Valgus Angle [E], mean ± SD (min-max)	7.90 ± 2.09 (5-10)	7.15 ± 4.65 (0-15)	7.40 ± 3.88 (0-15)	0.616
Posterior Tilt Angle [E], mean ± SD (min-max)	4.67 ± 3.00 (0-10)	4.20 ± 3.66 (0-11)	4.36 ± 3.38 (0-11)	0.657
Impaction [E], mean ± SD (min-max)	3.44 ± 2.35 (0-8)	2.25 ± 1.53 (0-5)	2.68 ± 1.91 (0-8)	0.487
Harris Hip Score, mean ± SD (min-max)	83.3 ± 14.1 (52.9-97.5)	86.9 ± 11.5 (71.5-99.5)	85.5 ± 12.5 (52.9-99.5)	0.441
VAS Score, mean ± SD (min-max)	1.1 ± 1.58 (0-4)	0.5 ± 0.82 (0-2)	0.74 ± 1.20 (0-4)	0.202
Union, mean ± SD (min-max)	2.1 ± 0.83 (1-3)	2.1 ± 0.57 (1-3)	2.07 ± 0.675 (1-3)	0.428
Post-op Complications, n (%)				0.040*
Yes	3 (25.0)	0	3 (11.1)	
No	9 (75.0)	15 (100.0)	24 (88.9)	
AVN, n (%)				0.100
Yes	2 (16.7)	0	2 (7.4)	
No	10 (83.3)	15 (100.0)	25 (92.6)	

Table 2: Patient post-operative outcome comparative data of parallel and inverted triangle designs.

*Significant, E AVN (2 cases) were excluded from total (27 cases) to get this variable (n = 25).

of the hip joint and two (7.4%) developed AVN (Figure 3) of femur head, but there were no cases of nonunion. However only one (3.7%) patient underwent total hip replacement. A significant (p = 0.04) finding was found when post-operative complications were studied between parallel screws against inverted triangle configuration. Table 3 summarizes the final operative outcome of this study.

Discussion

Valgus impacted and non-displaced neck of femur are essentially stable fractures for which few authors advised for conservative trial, mainly in few selected cases [4,25-27]. As per 2015 AAOS evidence-based guidelines for management of hip fractures in elderly with stable femoral neck fracture, moderate evidence supports operative fixation, although most authors believe in active intervention for these fractures [28]. Various internal fixation methods have been described and have been supported over other. Identifying the optimal technique for fixation to prevent or decrease the number of subsequent revision surgeries is a basic aim of every treatment. Surgical management of these fractures consists of internal fixation using cannulated cancellous screws, Dynamic Hip Screw, Femoral Neck System, or proximal femur plates.

In this study we found fairly good results with use of cancellous screws fixation as concurred in other previous studies [29]. All our patient's achieved union of their fractures. Although a few studies

Average time of union	Union of fracture	AVN femur head	Hip Arthritis	Change in walking pattern	Average Shortening of femoral neck
2.07 months	27 cases (100 %)	2 cases (7.4%)	3 cases (11.1%)	10 cases (37%)	0.96mm

Table 3: Final operative outcome of the study.

are mainly inconclusive regarding use of optimal implant when comparing sliding hip screw versus cancellous screws in undisplaced neck of femur fracture [30]. Xia., *et al.* in their meta-analysis in 2021 found higher incidence of AVN of femoral head with use of sliding hip screw in comparison with cancellous screws [31]. In our study only two patients (7.4%) had AVN but only one (3.7%) underwent total hip replacement surgery. Shehata et al. found lesser intraoperative blood loss with use of cancellous screws in comparison with sliding hip screw, which is also confirmed by our study as none of the patients needed blood transfusion during their hospital stay [32]. Vazquez., *et al.* reported comparable results upon using Femoral neck system, sliding hip screw and cancellous screws and similar good results are reported in our study using cancellous screws [33]. Lee., *et al*. had one (3.125%) case of non-union after cannulated screw in 32 patients, whereas in the current study there was no single case of non-union [34].

Cancellous screws offer a good option for fixation of stable femoral neck fractures and several configurations of the screws have been advocated. Partially threaded cancellous screws with four, three or two parallel screws, three screws configuration of divergent, triangle, inverted triangle or a biplanar double supporting screw fixation and fully threaded cancellous screws configuration are described for fixation. In this study 12 (40.7%) patients underwent fixation using 3 parallel screws configuration (Figure 1), whereas 15 (55.6%) patients had fixation via inverted triangle pattern (Figure 2). Selvan., *et al*., advocated use of the triangle (erect, inverted, anterior or posterior) configuration which showed higher peak load, higher ultimate load, less displacement, and more energy absorption before failure as compared to linear (2 or 3 parallel) configuration [35]. Yang., *et al*., corroborated the use of inverted triangle configuration of screws in his study and stated higher nonunion rate for triangle configuration [36]. Papanastassiou., *et al*., advocated use of divergent 3 cannulated screws instead of parallel configurations to have a better outcome and lesser complication rate [37]. In our study, upon comparison of inverted triangle and parallel screw configuration we too encountered statistically significant difference between the two groups regarding complication rate although no significant difference in union rate was seen. In two patients who had AVN and the one who developed hip arthritis, three parallel screws were used in fixation, which suggests that inverted triangle configuration is more favorable.

Figure 1: AP and Lateral radiographs of patient with parallel screw configuration. Pre-op (A and B) and post op (C and D).

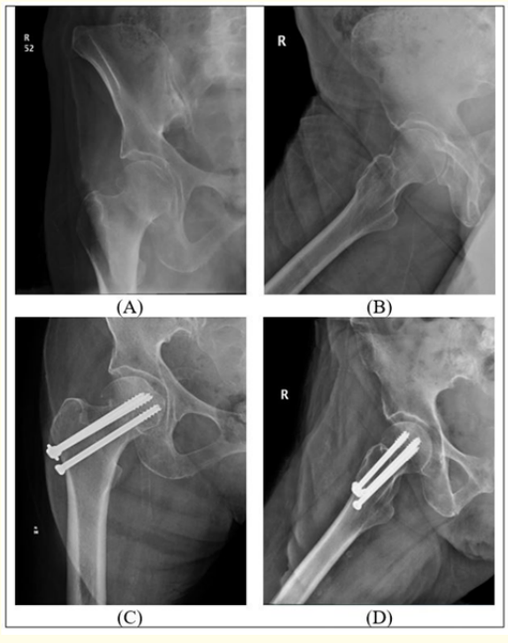

Figure 2: AP and Lateral radiographs of patient with inverted triangle screw configuration. Pre op (A and B) and post op (C and D).

Femoral neck shortening was seen in 9 patients ranging from 1-4mm. Five patients had an average shortening of 1.3mm (1-4mm) with 3 parallel screws, while 4 patients had an average shortening of 0.86mm (3-4mm) with inverted triangle design. Thus, relatively more shortening was detected in parallel screw type of fixation. Zlowodzki., *et al*., Shimizu., *et al*., and Faith trial found that increasing femoral shortening was associated with inferior hip function, whereas in our study only one patient with femoral shortening had poor outcome in Harris hip score [23,38,39]. Weil., *et al.* advocated use of fully threaded cannulated screws to decrease femoral neck shortening after fixation [40]. On the contrary, we did not face problems with use of partially threaded screws in majority of our patients.

Concerning reoperation rate, only one patient (3.7%) had Total Hip Replacement (THR) after avascular necrosis. The second case of AVN (Figure 3) did not need intervention as the patient had tolerable hip pain and refused a second stage surgery. Overmann., *et al*., reported a risk of reoperation of 14.1% and Kim., *et al*., reported 18.2% failure rate, but in current series all patients had union of their fractures [3,40].

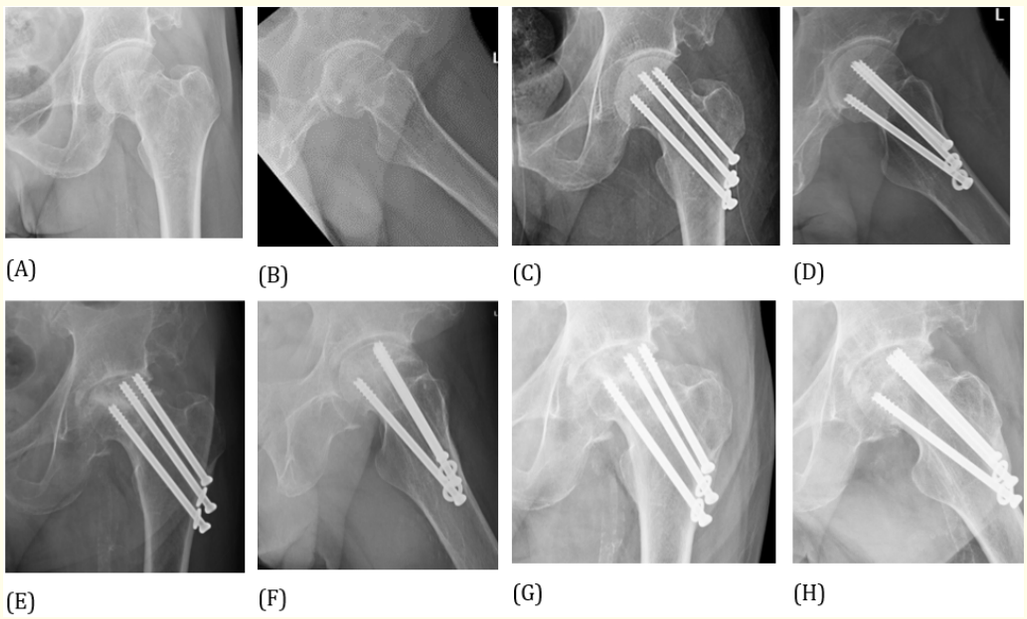

Figure 3: Radiograph of patient with post-operative AVN of femoral head. Pre op (A and B), immediate post-operative (C and D), partial collapse with early hip osteoarthritis at 1 year (E and F), 2-year post op with AVN and advanced OA (G and H).

We disagree with Moon., *et al*., recommendations of THR for patients older than 73 years as in our study all patients over 70 years achieved excellent results when screws were used in stable fracture fixation [12]. However, we support their opinion of avoiding internal fixation if posterior tilt was over 13 degrees as two of our patients who eventually developed AVN had posterior tilt angles of 15 and 22 degrees respectively. The limitation of our study is the small sample size which was an obstacle in achieving strong statistical recommendations.

Conclusion

Cannulated screws are a good option for fixation of stable femoral neck fractures in older patients. In this study, we found a statistically significant increase in complication rate with parallel screw design when compared to inverted triangle design. It was apparent that inverted triangle configuration had less femoral neck shortening and less rate of AVN, but to an extent that did not achieve statistical significance. However, all patients achieved union of their femoral neck fractures, 44.4% showed excellent and 18.5% showed good functional outcomes. Posterior tilt was found to be a predictor of poorer outcome with increased rate of AVN if tilt angle is more than 15 degrees although union of the fracture was achieved. Further prospective studies with larger number of patients are required.

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Conflict of Interest

No conflict of interest for any of the authors.

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