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Concomitant valgus hip osteotomy in operative fixation of displaced proximal femoral neck fractures

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Aims

Total hip arthroplasty (THA) is considered the preferred treatment for displaced proximal femoral neck fractures. However, in many countries this option is economically unviable. To improve outcomes in financially disadvantaged populations, we studied the technique of concomitant valgus hip osteotomy and operative fixation (VOOF). This prospective serial study compares two treatment groups: VOOF versus operative fixation alone with cannulated compression screws (CCSs).

Methods

In the first series, 98 hip fixation procedures were performed using CCS. After fluoroscopic reduction of the fracture, three CCSs were placed. In the second series, 105 VOOF procedures were performed using a closing wedge intertrochanteric osteotomy with a compression lag screw and lateral femoral plate. The alignment goal was to create a modified Pauwel's fracture angle of 30°. After fluoroscopic reduction of fracture, lag screw was placed to achieve the calculated correction angle, followed by inter-trochanteric osteotomy and placement of barrel plate. Patients were followed for a minimum of two years.

Results

Mean follow-up was 4.6 years (4.1 to 5.0) in the CCS group and 5.5 years (5.25 to 5.75) in the VOOF group. The mean Harris Hip Score at two-year follow-up was 83.85 in the CCS group versus 88.00 in the VOOF group ($p < 0.001$). At the latest follow-up, all-cause failure rate was 29.1% in the CCS group and 11.7% in the VOOF group ($p = 0.003$). The total cost of the VOOF technique was 7.2% of a THA, and total cost of the CCS technique was 6.3% of a THA.

Conclusion

The VOOF technique decreased all-cause failure rate compared to CCS. The total cost of VOOF was 13.5% greater than CCS, but 92.8% less than a THA. Increased cost of VOOF was considered acceptable to all patients in this series. VOOF technique provides a reasonable alternative to THA in patients who cannot afford a THA procedure.

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Introduction

Displaced proximal femoral neck fractures involving the proximal third of the femoral neck are challenging to treat. A displaced fracture in this region almost always disrupts the vascular supply to the femoral head, resulting in osteonecrosis and/or delayed fracture healing.[1,2] Total hip arthroplasty (THA) is considered the preferred treatment for these fractures.[3,4] However, many countries lack governmental healthcare and patients are unable to afford expensive procedures such as THA. Thus, cost becomes the primary deciding factor in determining treatment. Global rates of THA vary among countries, up to 38-fold, with correlation strongly linked to gross domestic product (GDP) and healthcare expenditures per capita.[5,6]

For treatment of displaced proximal femoral neck fractures in economically disadvantaged populations, the challenge is to improve outcomes within the affordability

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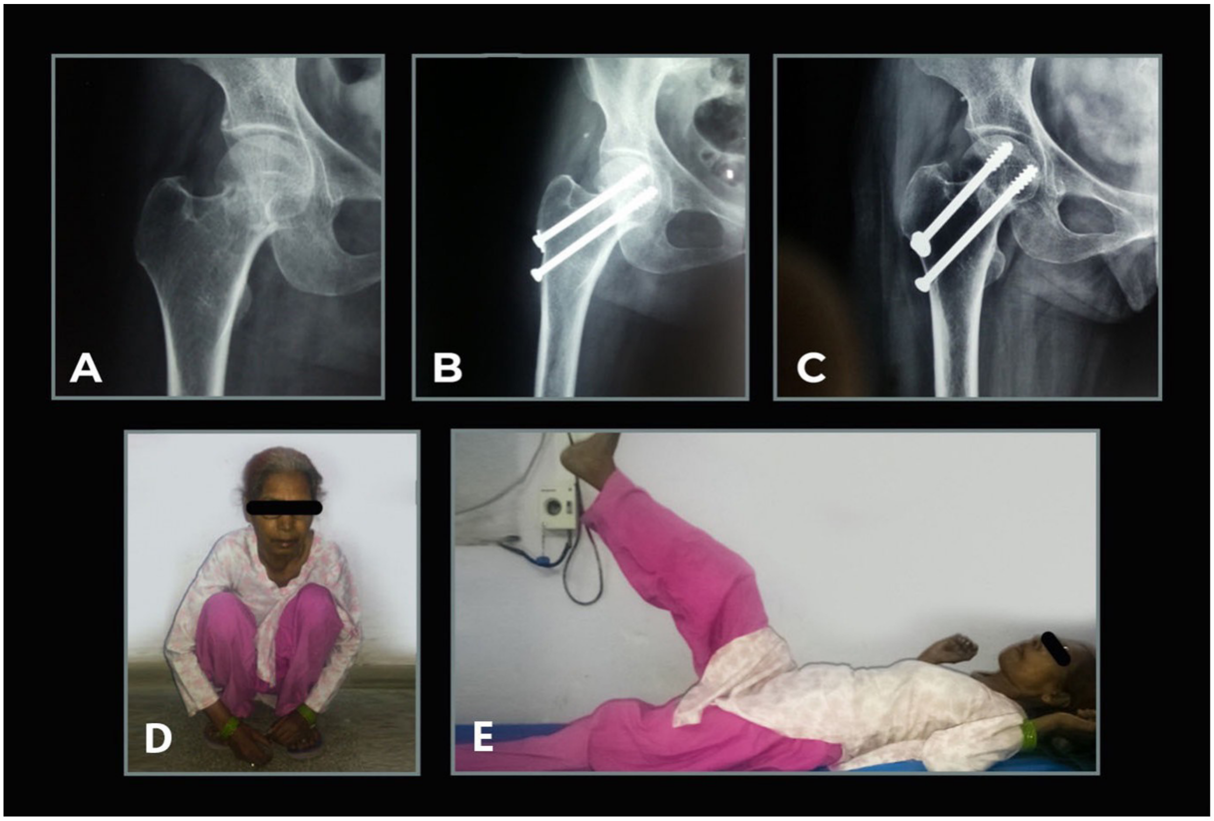

Fig. 1

Clinical case of cannulated compression screw (CCS) technique. a) Preoperative AP radiograph showing displaced Garden type 3 fracture. b) Postoperative radiograph showing closed reduction and internal fixation with CCS. c) Two-year radiograph shows healing of fracture. Femoral head shows no signs of osteonecrosis. d) and e) Patient capabilities at two-year follow-up (full squatting and straight leg raise).

envelope. We studied the technique of concomitant valgus hip osteotomy and operative fixation (VOOF) to improve clinical outcomes. The premise with the VOOF method is to reduce fracture shear stresses by converting the fracture interface towards compression. In turn, this reduces fracture site motion, allowing for a better chance of healing despite vascular disruption of the femoral head. We performed a prospective serial study of two treatment groups: VOOF versus operative fixation alone. Our hypothesis is that all-cause failure rate will be lower with the VOOF technique compared to operative fixation alone. Further, we hypothesize the total cost of the VOOF technique will be substantially less than a THA.

Methods

The two treatment groups were performed in consecutive order. This study received institutional review board approval and written informed consent was obtained from every patient. The inclusion criterion for the study was any patient admitted to the trauma unit with an acute (occurred within 21 days of presentation) displaced proximal femoral neck fracture. Exclusion criteria were undisplaced fractures, fractures which occurred more than > 21 days before presentation, neoplastic-related fractures, and fractures in patients with inflammatory arthropathy. All patients received preanesthetic medical clearance prior to surgery. The first author (AQK) performed all surgeries personally or with the senior resident and the author in attendance.

Surgical protocol. The first group was operative fixation only, employing a cannulated compression screw (CCS) technique. Between May 2004 and September 2010, 98 patients were enrolled. The CCS procedure was performed with the patient positioned supine on the fracture table (Technomed TMI 1206 Hanging Type Orthopaedic OT Table; Technomed, India). Fracture reduction was performed using fluoroscopic guidance. A limited lateral incision was made for screw insertion. The fixation device for all cases was the stainless steel CCS (Madura Ortho, Delhi, India). Guide pins were inserted into the femoral head and 6.5 mm cannulated screws were inserted over the guide pins. Screw position followed the guidelines as described by Pabinger and Geissler.[5] Fracture stability, screw length, and screw position were confirmed fluoroscopically in orthogonal views. A clinical demonstration of CCS technique is illustrated in Figure 1.

The second group underwent the VOOF technique. Between November 2010 and November 2020,

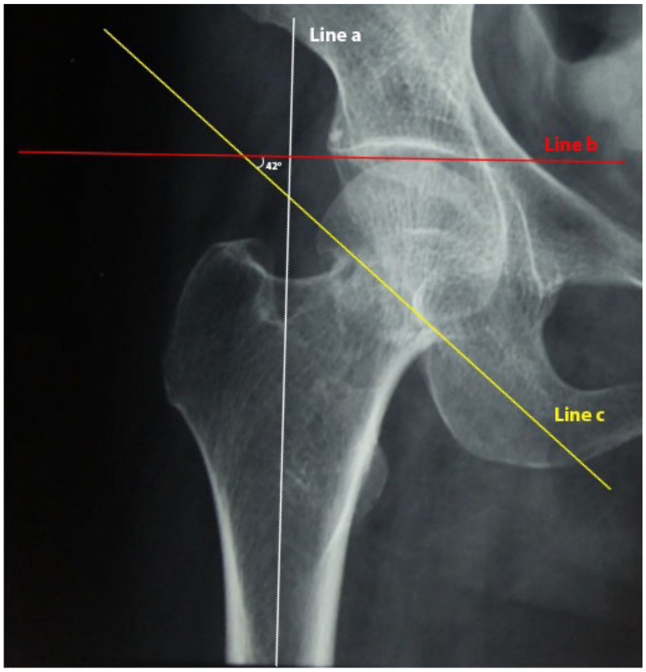

Fig. 2

Simulated intraoperative planning for valgus hip osteotomy and operative fixation. Fluoroscopic image of right hip fracture showing calculation of modified Pauwel's angle. First, a longitudinal axis of the femur is identified (line a). Second, a line is made perpendicular to the longitudinal axis (line b) to the level of the superior edge of the femoral head. Third, a line is made along the subcapital fracture line (line c) to line b. Pauwels angle is the acute angle subtended by line b and c. Fourth, the calculated correction angle (CCA) is Pauwel's angle – 30°. In this example, Pauwel's angle is 42°. The CCA is 12°. Thus, the wedge angle in the osteotomy is also 12°.

105 patients were enrolled in the study. Operative planning was performed after reducing the femoral neck fracture (Figure 2), using the fluoroscopic images for correction calculations. First, the calculated correction angle (CCA) was determined measuring the modified Pauwel's angle (MPA).[6] The longitudinal axis of the femoral diaphysis was identified. Next, a line was made perpendicular to the femoral longitudinal axis. Fracture inclination (i.e. the MPA) was defined as the angle subtended by the perpendicular line with the fracture line. This was measured digitally on the screen monitor. The goal for the osteotomy was to reduce the MPA to 30°. Hence, the CCA was calculated as: MPA minus desired angle of 30°. The CCA was used as the osteotomy wedge angle for the valgus intertrochanteric osteotomy.

The VOOF procedure was performed with the patient positioned supine on a fracture table. A lateral proximal femoral incision was used. The fixation device for all cases was the double-angled Dynamic Hip Screw (DHS) with a side plate (Madura Ortho, India). The stepwise VOOF technique is illustrated in Figure 3. A guide pin was placed into the femoral head with fluoroscopy. Pin insertion angle (PIA) is the angle subtending the lateral femoral cortex and the angle of the DHS screw (120°)

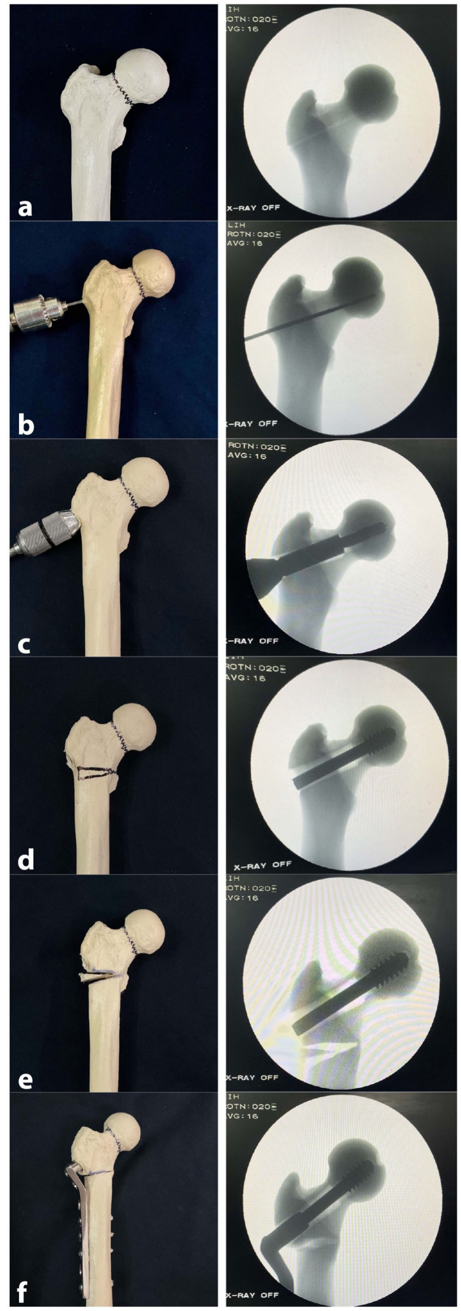

Fig. 3

Step-wise demonstration of intraoperative technique of valgus hip osteotomy and operative fixation (saw bone model). a) The subcapital fracture is anatomically reduced. b) The pin insertion angle (PIA) is calculated. The PIA is 120° (dynamic hip screw (DHS) barrel angle) – calculated correction angle (CCA). This will allow the DHS plate to sit flush with the lateral femoral cortex after the osteotomy is made. c) A guidewire is placed into the femoral head at the PIA and then prepared for insertion of the lag screw using the DHS Triple Reamer. d) The lag screw is inserted to within 2 to 4 mm of the subchondral plate, confirmed in orthogonal views. e) A transverse osteotomy cut is made at the level of lesser trochanter (but not through the medial cortex). The second oblique cut is made to equal the CCA. We emphasize that the saw cuts do not violate the medial femoral cortex. f) The lateral plate is connected to the lag screw and the osteotomy is closed with an audible snap. Cortical transverse screws are placed in compression mode to compress the osteotomy site. Finally, a compression screw is placed in the lag screw to compress the neck fracture.

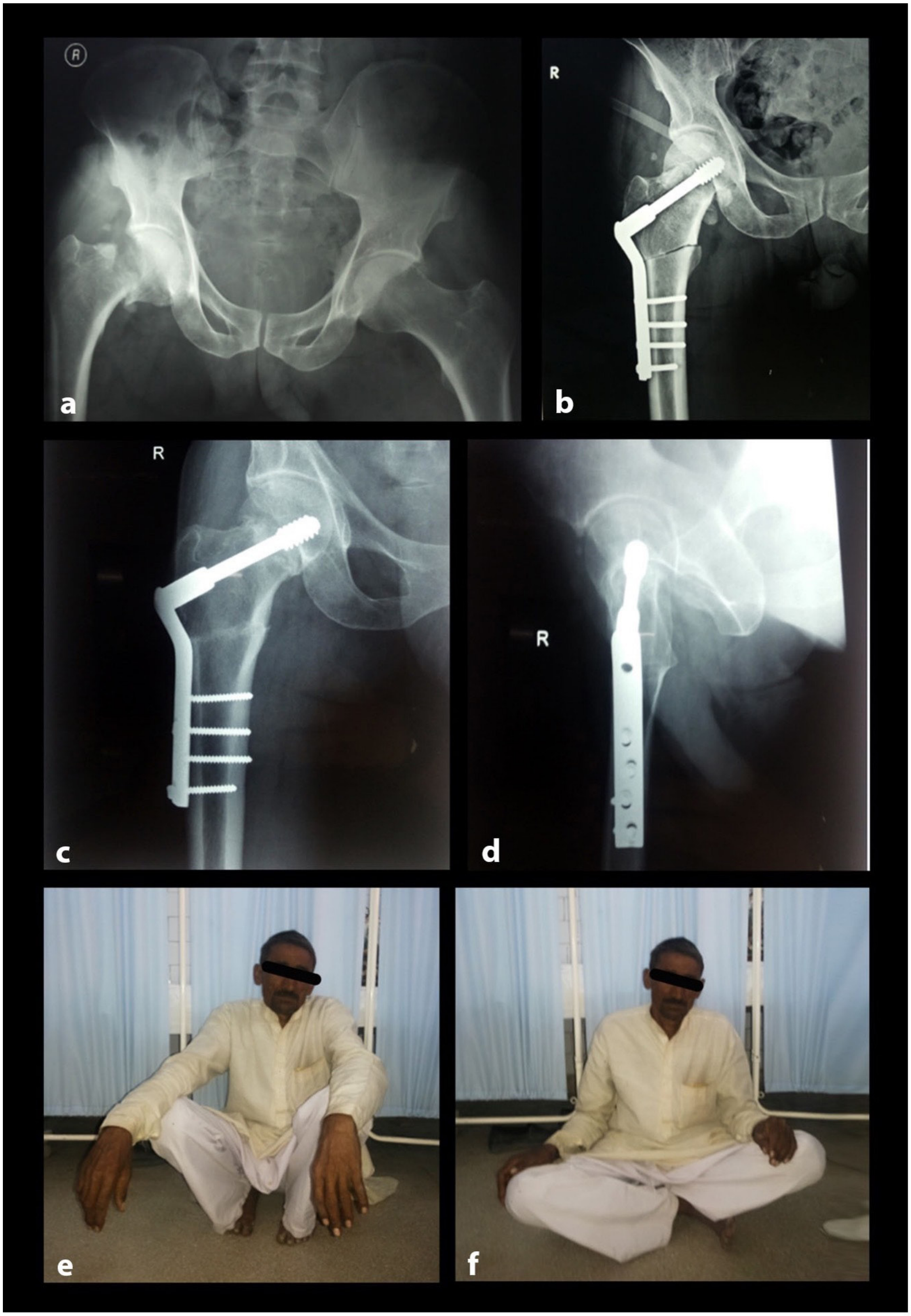

Fig. 4

Clinical case of the valgus hip osteotomy and operative fixation technique. a) Preoperative pelvic radiograph showing right Garden 3 fracture neck of femur. b) Postoperative radiograph showing intertrochanteric osteotomy and fracture fixation using a double-angled dynamic hip screw. c) and d) Three-year radiograph showing healing of fracture and osteotomy union. No osteonecrosis is visualized. e) and f) Patient capabilities at three-year follow-up (full squatting and cross-legged sitting).

Table I. In-hospital medical complications in valgus hip osteotomy and operative fixation and cannulated compression screw.

Complication	CCS, n (%)	VOOF, n (%)
Any cardiac complication	2 (2)	3 (2.9)
Any pulmonary complication	1 (1)	2 (1.9)
Gastrointestinal bleeding	0 (0)	1 (0.9)
TIA/Stroke	1 (1)	0 (0)
Hypotension requiring vasopressors	1 (1)	0 (0)
DVT/PE	1 (1)	0 (0)
UTI	2 (2)	2 (1.9)
Renal failure	2 (2)	3 (2.9)
Decubitus wound	5 (5.2)	3 (2.9)
Total	15 (15.6)	14 (13.7)

CCS, cannulated compression screw; DVT, deep vein thrombosis; PE, pulmonary embolism; TIA, transient ischaemic attack; UTI, urinary tract infection; VOOF, valgus hip osteotomy and operative fixation.

Table II. All-cause failures in the valgus hip osteotomy and operative fixation and cannulated compression screw groups.

Failure (cause)	CCS, n (%)	VOOF, n (%)	p-value*
Hardware failure	2 (2)	0 (0)	0.234
Fracture nonunion	2 (2)	1 (0.9)	0.612
Osteotomy nonunion	N/A	0 (0)	> 0.999
Chronic infection	2 (2)	2 (1.9)	> 0.999
Osteonecrosis (Ficat-Arlet ≥ 3)	12 (10.4)	4 (3.9)	0.036
Articular degeneration (Tönnis 3)	8 (8.1)	4 (3.9)	0.240
Harris Hip Score < 70	2 (2.0)	1 (0.9)	0.612
Total	28 (29.1)	12 (11.7)	0.003

*Fisher's exact test.
CCS, cannulated compression screw; N/A, not applicable; VOOF, valgus hip osteotomy and operative fixation.

minus the CCA (Figure 3). This allows the lateral plate to seat flush to the lateral femoral cortex after completing the osteotomy. An 8.0 mm diameter lag screw was inserted to within 3 mm of the femoral head subchondral plate and ensuring the lag screw threads completely crossed the fracture. Fracture stability, screw length, and screw position were confirmed fluoroscopically in orthogonal views. Next, the valgus intertrochanteric closing wedge osteotomy was performed using fluoroscopic guidance. The proximal cut was made transversely at the level of the lesser trochanter. The selected CCA was measured on the fluoroscopic image intensifier using software (Siemens Multimobil 5E, Germany). The distal wedge cut was performed and the two bone ends opposed. The osteotomy cuts were made just to the edge of the medial cortex, such that when closing the wedge an audible/palpable crack was noted. The lateral plate was then placed, first engaging the barrel onto the lag screw. The plate was secured to the lateral femoral cortex using bi-cortical screws in a compression setting, compressing the osteotomy. A compression screw was inserted through the barrel into the lag screw in every case. A clinical demonstration of the VOOF technique is illustrated in Figure 4.

All patients started physiotherapy on the first postoperative day, with limited weightbearing with a walker or crutches. Patients were progressed to full weightbearing in both groups at 12 weeks if radiographs showed bone healing. Patients were seen at two weeks, six weeks, 12 weeks, six months, one year, and yearly thereafter. Any complications in treatment or return to the operating room were recorded. Hip function was assessed by surgeon review of gait, passive hip range, and limb strength. Patient hip function was recorded using the Harris Hip Score.[7] Radiographs were taken at the designated assessment visits. Digitized radiographs included an anteroposterior (AP) view of the pelvis, and AP and lateral view of the hip to include the proximal femur and implants. On preoperative radiographs, the proximal hip fracture was classified according to Garden.[8,9] Postoperative radiographs at each interval were reviewed for the following: bone healing, changes in femoral head position, hardware migration/failure, the presence of femoral head osteonecrosis, and articular degeneration. Osteonecrosis, when present, was graded using the system described by Arlet and Ficat.[10] Articular degeneration, when present, was rated according to the classification described by Tönnis.[11] The ratings of osteonecrosis and articular degeneration were performed by reviewing the two-year follow-up radiographs for each patient. Two radiologists (SA, MA) rated each patient's radiographs with their scores averaged. The interobserver correlation coefficient was calculated using the intraclass correlation coefficient (ICC) method.

Cost analysis. A cost analysis of the two fracture treatment groups was compared to the costs of THA. A total of 20 cases from each treatment group were randomly selected for review. In addition, 20 elective THA cases (performed by AQK) for noninflammatory coxarthrosis were selected. The elective THA group served as proxy for THA for a displaced proximal femoral neck fracture, because no cases of proximal hip fracture were treated with THA. Total costs were calculated by reviewing the summary expense bill provided at discharge to all patients. Total costs included costs incurred (i.e. surgeon fees and implant costs) from the time of hospital admission until the time of discharge.

Statistical analysis. The statistical analysis was performed using the SPSS Statistics 28 package (IBM, USA). The chi-squared test was used to determine statistically significant relationships between nominal variables. Fisher's exact test was used to compare the distribution of complications, failures, and reoperations between the CCS and VOOF groups. Additionally,an independent-samples *t*-test was used to compare the mean HHS, operating time, and hospital length of stay between the CCS and VOOF groups. Survival analysis was conducted using

Kaplan-Meier survival curves. A p-value < 0.05 was considered statistically significant.

Results

In the CCS group (n = 98), there were 58 females and 40 males. The mean age was 47 years (29 to 64). Mean follow-up was 4.6 years (4.1 to 5.0). Two patients (2%) were lost to follow-up. The mean operating time defined as time from "wheels in to wheels out" was 68 minutes (standard deviation (SD) 7). During the entire study period, no patient died while in hospital. The mean hospital length of stay was 12 days (5 to 19). There were 15 medical complications (15.6%), with no significant differences between the groups. The in-hospital medical complications are listed in Table I. There were 29 reoperations in 28 patients. The type and number of reoperations are listed in Tables II and III. There were two deep infections (2%), of which one was treated successfully with surgical debridement. The other patient required multiple surgical debridements followed by Girdlestone arthroplasty. Two patients (2%) had hardware failure with screw pull-out or screw cut-out, for which hardware removal was required. Two patients (2%) developed nonunion of the femoral neck and both underwent surgical conversion to hemiarthroplasty after six-month follow-up. A total of 12 patients (12.5%) developed radiological osteonecrosis with femoral head collapse at six-month follow-up. Eight patients (10.4%) had advanced hip degeneration (Tönnis 3) at two-year follow-up. At the two-year follow-up, mean HHS of the surviving CCS cases was 83.85 (59 to 99), and only two patients (2.0%) had a HHS < 70.

In the VOOF group (105 patients), there were 68 females and 37 males. The mean age was 58 years (30 to 75). Mean follow-up was 5.5 years (5.25 to 5.75). Three patients (2.9 %) were lost to follow-up. The mean operating time was 105 minutes (SD 12). During the entire study period, no patient died while in hospital. The mean hospital length of stay was seven days (4 to 10). There were 14 medical complications (13.7%) in 102 patients. The complications are listed in Table I. There were 13 reoperations in 12 patients. The type and number of reoperations are listed in Table II and Table III. There was one deep infection (0.9%) that required surgical debridement twice. All osteotomies had successful bone union. Overall, 101 patients (99 %) healed their proximal hip fracture with one case of nonunion (0.9%). Four patients (3.9%) developed osteonecrosis with femoral head collapse. At two-year follow-up, four patients (3.9%) had advanced hip degeneration (Tönnis 3). At two-year follow-up, mean HHS of the surviving VOOF cases was 88 (60 to 100), where only one patient (0.9%) had a HHS < 70.

Table III. Reoperations performed in the valgus hip osteotomy and operative fixation and cannulated compression screw groups.

Reoperations	CCS, n	VOOF, n	p-value*
Hardware removal only	2	0	0.234
Deep infection debridement	3	2	0.675
Conversion to Girdlestone	1	0	0.485
Conversion to hemiarthroplasty	11	4	0.059
Conversion to THA	12	5	0.075
Total	29	13	0.003

*Fisher's exact test.
CCS, cannulated compression screw; THA, total hip arthroplasty.

A comparative analysis between the CCS and VOOF groups showed no statistical difference in age, sex, mortality, medical complication rates, and patient demographics. In the VOOF group, operating time and hospital length of stay were significantly longer (p < 0.001, independent-samples *t*-test). There were significantly more reoperations in the CCS group (p = 0.003 Fisher's exact test). Mean HHS at latest follow-up was statistically better in the VOOF group (p < 0.001, independent-samples *t*-test). There was a higher occurrence of osteonecrosis in the CCS group (12/96) as compared to VOOF (4/102) (p = 0.036, Fisher's exact test). The rate of hip degeneration (Tönnis ≥ 3) was greater in the CCS group, although the result was not statistically significant (p = 0.240, Fisher's exact test).

Survival analysis. A Kaplan-Meier survival analysis was performed comparing the two treatment groups (Figure 5). Both groups were analyzed by all-cause failure rate. Failure was defined as a conversion procedure, femoral head nonunion, chronic infection, osteonecrosis with head collapse, Tönnis 3 articular degeneration, and HHS ≤ 70. All-cause failure rate was higher in the CCS group (28/96) versus the VOOF group (12/102) (p = 0.003).

Cost analysis. The mean total costs for the study procedures is presented in Table IV, with comparison to elective THA. The mean cost of the CCS technique was Indian National Rupees (INR) 5,820 and the VOOF technique was INR 6,725. The VOOF was 13.5% more costly than CCS. However, the cost of the VOOF technique was only 7.2% of the cost of an uncemented primary THA procedure (INR 92,250). Even though the VOOF technique was more expensive than the CCS, all patients were able to afford the VOOF procedure.

In this study, the total difference in costs between a VOOF and CCS was INR 1,35,765 (105 × 6,725 vs 98 × 5,820). This prevented 16 reoperations at an average cost of INR 38,000 per procedure. The total savings with VOOF was INR 6,08,000 (16 × 38,000). The total calculated net savings was INR 4,72,235. The hip fractures incidence in India is 105 and 159 per 100,000 males and females, respectively,[12] equating to approximately 22,400 hip fractures/year, of which 20,160 of these fractures are displaced. If the VOOF method were to be employed

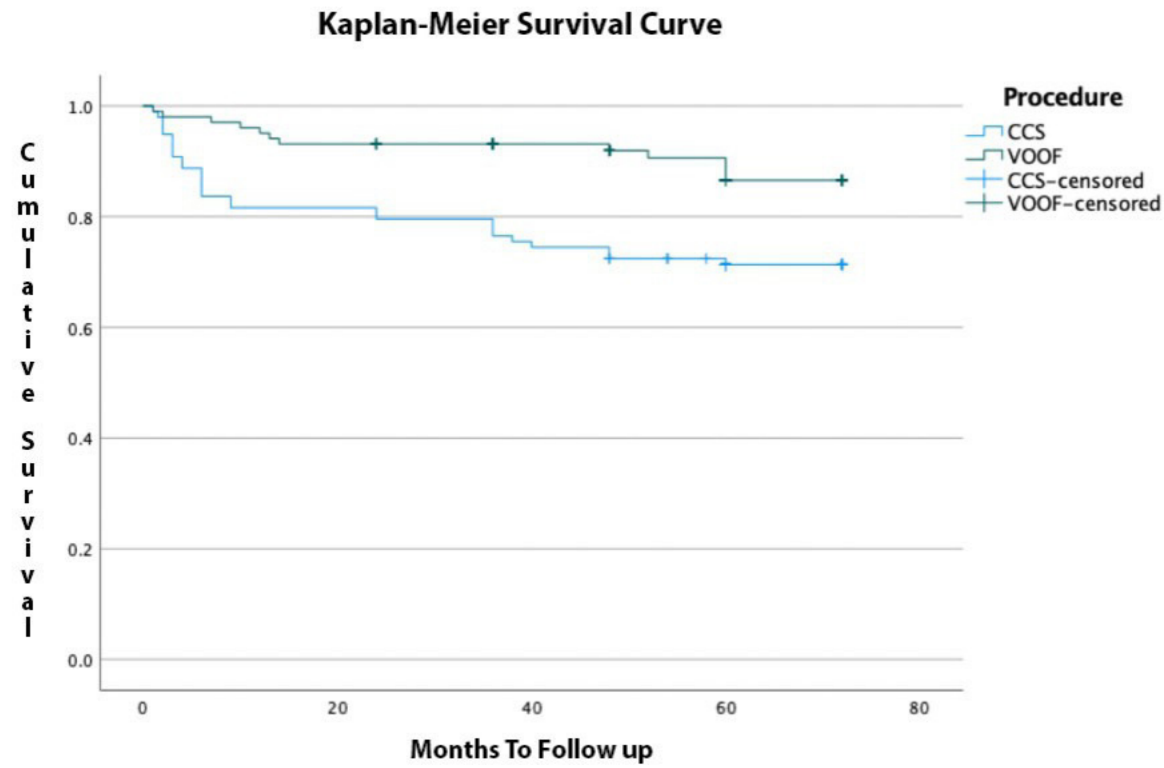

Fig. 5

Kaplan-Meier survival curve comparingvalgus hip osteotomy and operative fixation (VOOF) to cannulated compression screw (CCS). The curve demonstrates a significantly improved survival with VOOF procedure as compared to CCS.

Table IV. Cost analysis of valgus hip osteotomy and operative fixation vs cannulated compression screw vs cementless total hip arthroplasty. Costs are given in Indian National Rupees.

Procedure	Implant cost	Perioperative medications	Hospital charges	Fluoroscopy charges	Total costs
CCS	915	4,500	155	250	5,820
VOOF	1,685	4,500	290	250	6,725
THA*	80,000	6,500	5,500	250	92,250

*Zimmer-Biomet Trilogy Porous acetabular component, Longevity polyethylene liner, Versys (CoCr) head and Porous ML Taper stem system for all THA cases.
CCS, cannulated compression screw; THA, total hip arthroplasty; VOOF, valgus hip osteotomy and operative fixation.

in all displaced proximal femoral neck fractures, the extrapolated savings to Indian healthcare would be INR 9.5 billion per year (approximately €95 million/year).

Discussion

Arthroplasty is considered the optimal treatment for displaced proximal femoral neck fractures in countries that can readily afford this procedure.[13,14] The procedure allows immediate mobilization and reduces healthcare costs by avoiding reoperations due to nonunion, femoral head osteonecrosis with collapse, and hip joint degeneration.[14,15] However, hip arthroplasty implants are high precision technology devices, employing advanced engineering, biomaterials, and machining. Compared to devices for fracture fixation, the costs to produce, distribute, and maintain a multisize inventory of hip arthroplasty parts anywhere in the world is far costlier per annum than maintaining hip fracture fixation inventory. In countries where government-sponsored healthcare is limited, the costs of a THA for acute proximal hip fracture treatment are prohibitive for individual patients who must pay directly to the hospital provider.

An alternative to THA is to modify available operative fixation methods that fit within the "affordability envelope" within each country. The proximal femoral neck fracture is difficult to treat for several reasons. First, the fracture occurs in a mechanically disadvantaged area. With the average hip neck-shaft angle being 120°, a proximal neck fracture imparts a significant shear angulation to the fracture.[16,17] Minimizing fracture motion in cancellous bone with screws is difficult. Any load bearing of the fracture, even with limited weightbearing, is going to impart interface shear at the fracture site. The result is increased fracture motion. Second, with displaced Garden Type 3 and 4 fractures, there is a high incidence of femoral head devascularization.[18] In the adult hip, femoral head blood supply is primarily from the ascending branch of the medial femoral circumflex artery, which delivers blood supply to the superior epiphyseal branches supplying the femoral head.[19-21] Fracture displacement disrupts this blood supply. Thus, fracture healing/remodeling will proceed only from the distal femoral neck. As a result, fracture healing time is increased. Moreover, the risk of femoral head osteonecrosis is significant. In Garden Type 3 and 4 fractures, the reported incidence of osteonecrosis is as high as 16%.[22] The unknown question is whether the natural progression of necrotic collapse can be altered while obtaining fracture union.

This study showed the VOOF technique improved survivorship compared to CCS. Fracture union not requiring any reoperation (all cause failure) was 88.3% in the VOOF group compared to 70.9% in the CCS group. There was a significantly lower rate of reoperation in the VOOF group, and mean HHS at two-year follow-up was significantly better compared to CCS. Additionally, there was a significantly lower rate of osteonecrosis in the VOOF group. We believe that by performing the valgus osteotomy, fracture healing is improved by providing compression stability of the fracture. With a stable fracture, regenerative neovascularization of bone occurs from the distal femoral neck fragment toward the femoral head at a limited rate. The gradual vascular regeneration has the salutary effect of limiting bone collapse of large avascular segments of the femoral head. It is our contention, as espoused by Pauwel,[6] that the major reason for failure in displaced femoral neck fracture treatment is mechanical failure, and not from osteonecrosis.

Finally, our analysis showed that the VOOF technique is cost-effective compared to CCS. The 13.5% additional cost of the VOOF prevented 16 reoperations and markedly improved patient quality of life. Furthermore, the cost of VOOF was far less than a THA. At our institution, patients pay for their procedure directly to the hospital as there is no government-sponsored healthcare. During this study, all patients were able to afford the additional 13.5% in costs of the VOOF. Based on our results, we feel that the VOOF technique fills a niche that improves clinical outcomes at a nominal increase in cost. This is vitally important in financially disadvantaged populations.

From the recent Hip Fracture Evaluation with Alternatives of Total Hip Arthroplasty versus Hemiarthroplasty (HEALTH) trial, hemiarthroplasty (HA) was capable of maintaining functional ambulation in patients comparable to THA.[23] In a theoretical cost analysis of the THA group, if HA implants were to be used instead, the treatment cost saving would be only 17.5% of THA. This is still far out of reach for our treatment population in this study.

We acknowledge several weaknesses of the study. First, the study was not randomized due to the lack of resources. Our hospital is the main regional receiving centre for trauma and indigent care. Hospital funding is limited and there are scarce resources available to coordinate the intricacies of a randomized trial. The best that could be managed was to perform each technique in series. Although not perfect, we believe this method to be superior to a retrospective matched cohort observational study, as the prospective serial study does remove surgeon selection bias. However, with a serial consecutive series, we acknowledge a wisdom bias, as the second group is biased towards better results. Second, approximately 3% of patients were lost to follow-up. This is not unusual in our population where patients come from outside cities and decide not to return due to limited finances and transportation. Lastly, this study would have better strength had the study included a study arm treated with THA. Unfortunately, for financial reasons, this option of treatment was not possible. Furthermore, in the future, this study should be validated by different surgeons at various institutions.

In summary, for treatment of displaced proximal femoral neck fractures, the VOOF technique improved survivorship compared to operative fixation alone with CCS. Although more technically demanding to perform, the medical complication rate in the VOOF was similar to CCS. The nominal increase in cost of the VOOF compared to CCS was acceptable to this cohort of patients who face financial hardship. While more expensive than CCS, the VOOF technique is still far less expensive than THA. We feel that the VOOF technique fills a specific niche where surgical procedures are selected more by their costs than their overall effectiveness.

Take home message

- Treatment of displaced proximal femoral neck fractures is a challenging problem in economically deprived populations where total hip arthroplasty (THA) is not affordable.
- We studied a technique of a concomitant valgus intertrochanteric osteotomy and operative fixation (VOOF) for the proximal neck fracture using a lag screw and compression plate to improve healing and patient function as an affordable alternative to THA.
- We performed a prospective serial study comparing two consecutive series: operative fixation using three cannulated compression screws (CCSs) to VOOF.
- The VOOF technique improved survival compared to CCS and was 92.8% less expensive than a THA.
- The VOOF technique is an acceptable alternative to CCS when a patient cannot afford a THA.

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