Screw versus helical proximal femoral nail in the treatment of unstable trochanteric fractures in the elderly

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ABSTRACT

Purpose: Comparison of clinical, radiological and functional outcomes of screw proximal femoral nail (PFN) and helical PFN in management of unstable trochanteric fractures.

Methods: This prospective randomised comparative study included 60 patients with closed unstable intertrochanteric fractures (AO classification-A2.2–A2.3 & A3.1–A3.3). Patients were randomised to 2 treatment groups using simple random sampling method utilizing computer based randomisation. Screw PFN and helical PFN were used for internal fixation with 30 patients in each group.

Results: Both groups were similar in respect of age, gender, fracture classification, quality of fracture reduction, duration of hospitalization, post-operative complications, residual/late deformity as well as functional assessment. However, mean duration of surgery was significantly lower (23.1%) in helical PFN group as compared to screw PFN group (43.32 ± 8.20 min vs. 35.20 ± 6.03 min, $p < 0.001$). Furthermore, mean blood loss was not significant in either of the study groups but it was significantly lesser (30.1%) in helical PFN group as compared to screw PFN group (77.80 ± 17.39 ml vs. 59.80 ± 14.96 ml, $p < 0.001$). Also, mean number of images taken was significantly lower (58.7%) in helical PFN group as compared to screw PFN group (29.52 ± 4.85 no vs. 18.60 ± 3.12 no, $t = 9.47$; $p < 0.001$).

Conclusion: Both screw PFN and helical PFN are equally effective implants in internal fixation of unstable trochanteric fractures with no statistically significant difference ($p > 0.05$) in any of the outcome measures. However, helical PFN group fared marginally better in terms of operative time, blood loss and imaging required.

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1. Introduction

With the increasing life expectancy, the incidence of trochanteric fractures is progressively increasing and is likely to be more than 4.5 million by 2050.^{1,2} These geriatric patients have multiple medical co-morbidities (e.g. diabetes mellitus, hypertension, pulmonary, renal and cardiac problems) adding to the insult of the injury as well as making them highly susceptible to infections and postoperative complications like hypostatic pneumonia, decubitus ulcer and cardiorespiratory failure.³ Over 700,000 deaths are estimated annually worldwide due to hip fractures and the one year mortality after surgery is reported to range between 15% and 30%.^{3,4} Most of these fractures need operative treatment in form of stable

fixation with a device which allows rapid surgery and permits early mobilization including weight bearing as most of these older patients are unable to restrict weight bearing during ambulation.

The optimal implant for fixing trochanteric fractures remains debatable. Dynamic hip screw (DHS), the most popular extramedullary fixation device, has often been considered the gold standard for surgical stabilization of trochanteric fractures.⁵ However, the clinical value of DHS is limited in unstable and reverse oblique trochanteric fractures where it often fails to give good results.⁶ Ever since their advent in 1990s, intramedullary fixation devices have become increasingly popular, especially in the treatment of unstable trochanteric fractures, due to various biomechanical advantages compared with extramedullary fixation.^{7–10} Amongst these intramedullary devices, proximal femoral nail with two proximal screws (screw PFN) have been widely used because of its excellent clinical results.¹¹ However, screw PFN is not without its own share of unique problems including varus collapse, z-effect, reverse z-effect, implant cut out and intra-as well as post-

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operative femoral shaft fractures.^{12,13} Proximal femoral nail with helical blade (helical PFN) has been designed to decrease these implant related complications and as an improvement over proximal femoral nails with two proximal screws. Over the last 10 years, helical PFN is gradually gaining popularity due to better purchase of helical blade in bone which gets compacted around it leading to higher cut out resistance.¹⁴

Although there are multiple studies comparing screw PFN with DHS and other intra-medullary devices like Gamma nail, limited studies are available which compares treatment outcomes of screw PFN with helical PFN.^{15–17} In view of the extremely limited literature available, we conducted this prospective randomised study to compare the clinical, radiological and functional outcomes of screw PFN and helical PFN in management of unstable trochanteric fractures.

2. Materials and methods

2.1. Study population

This prospective, randomised comparative study was conducted at Military Hospital Kirkee over a period of 24 months and included 60 patients with closed unstable intertrochanteric fractures (AO classification-A2.2–A2.3 & A3.1–A3.3) with minimum follow-up of 12 months and maximum follow-up of 2 year. Inclusion criteria were: patients above the age of 50 years; independently ambulant before injury; closed unstable trochanteric fracture classified as AO A2.2–A2.3 & A3.1–A3.3. Exclusion criteria were: age less than 50 years; pathological fracture of any cause other than osteoporosis, open fractures, inability to walk independently prior to injury event; neurological and psychiatric disorders that would preclude assessment (e.g. Parkinsonism, multiple sclerosis, severe depression). All patients were included in the study after obtaining informed written consent. This study was approved by ethics committee at our hospital. Patients were randomised to 2 treatment groups using simple random sampling method utilizing computer based randomisation with Microsoft Excel software.

2.2. Surgery and postoperative management

Surgery was performed on fracture table in supine position under regional anaesthesia (combined spinal and epidural anaesthesia) by the on-call surgeon or under his supervision by a resident. Closed reduction of fracture was done by manipulation using fracture table under radiological control by image intensifier. Internal fixation of fracture was done using two types of intra-medullary devices: Screw PFN and helical PFN. For both the devices, the lag screw was aimed to be placed in central inferior neck in coronal plane (AP view) and central femoral neck in sagittal plane (lateral view) with its tip between 5 and 10 mm from subchondral bone (tip apex distance of less than 20 mm).¹⁸ Distal locking was done using implant specific distal locking jig, followed by layered wound closure. Both the implant designs had a similar caput-collum-diaphyseal (CCD) angle of 130°. The quality of the fracture reduction was quantified by the measurement of the post-operative fracture gap and the Garden Alignment Index.²⁰ The implant position in the femoral head was documented via the Cleveland zones^{21,22} and the Tip Apex Distance (TAD).^{18,23} The TAD was calculated by measuring the distance between the tip of the proximal implant (lag screw) to the apex of the femoral head on the AP and lateral X-ray after Baumgaertner's formula.²³

We assessed the duration of surgery, blood loss and intra-op imaging requirements at different steps of surgery. To assess the postoperative outcome, X-rays were calibrated. The pictures were adjusted for magnification by multiplying the measured distances

on both AP and lateral X-rays by the ratio of the true to measured lag screw diameter.

A 3rd generation cephalosporin was used for antibiotic prophylaxis for first 24 h only with first dose being administered at induction of anaesthesia. Post-operatively, patients were mobilized early as per institutional protocol with protected weight bearing (partial weight bearing) on day one after the operation. Soluble aspirin along with anti-embolism stockings were given for 6-weeks as thromboprophylaxis in most cases which could be mobilized early within first 24 h postoperatively whereas low molecular weight heparin was used if there was any delay in mobilizing the patient. Ambulation with weight bearing as tolerated was continued till radiological evidence of union. Each patient was followed up post-operatively clinically, radiologically and functionally at 6 weeks, 03 months, 06 months and 1 year. The functional results were assessed using Modified Harris Hip Score system. We assessed radio graphs for progress of union of fracture, varus collapse, shortening of femur, cut out of femoral head, z-effect and implant breakage. Patients' functional outcomes were measured with help of Harris hip score.²⁴

3. Results

3.1. Population characteristics

A total of 60 patients were recruited and randomised equally to be treated either with screw PFN ($n = 30$, mean age = 64.36 ± 8.28 years) or helical PFN ($n = 30$, mean age = 65.36 ± 8.66 years). There was no significant statistically difference between the two groups for age, gender or AO classification of fracture ($p > 0.05$). The population characteristics of two groups are summarized in Table 1.

3.2. Operative details

The operative details of two groups are summarized in Table 2. Acceptable fracture reduction was achieved by closed manipulation on fracture table in all cases (100.0%). However, mean duration of surgery was significantly lower (23.1%) in helical PFN group as compared to screw PFN group (43.32 ± 8.20 min vs. 35.20 ± 6.03 min, $t = 3.99$; $p < 0.001$). Further, mean blood loss was not significant in either of the study groups but it was significantly lesser (30.1% lesser) in helical PFN group as compared to screw PFN group (77.80 ± 17.39 ml vs. 59.80 ± 14.96 ml, $t = 3.92$; $p < 0.001$). There was no statistically significant difference for blood transfusion requirement between the two groups (33.3% vs. 23.0%, $\chi^2 = 0.80$; $p = 0.370$). Also, mean number of images taken was significantly lower (58.7%) in helical PFN group as compared to screw PFN group (29.52 ± 4.85 no vs. 18.60 ± 3.12 no, $t = 9.47$; $p < 0.001$).

3.3. Hospital stay and immediate post-operative complications

The hospital stay duration and incidence of post-operative complications, i.e. wound infection, thromboembolism and pressure sores, of two groups are summarized in Table 3. There was no statistically significant difference between both the groups in terms of both hospital stay duration and incidence of any of the post-operative complications. Superficial infection in all cases was successfully managed by local wound care and antibiotics only, without any requirement of surgical debridement.

3.4. Implant related complications

The implant related complications, i.e. periprosthetic fracture, cut out/Z-effect, implant breakage, reoperation and non-union of

Table 1

Basic characteristics of two groups at admission.

Basic characteristics	PFN (n = 30)	PFNA (n = 30)	p-value (Student's t-test)
Age (years): Mean $\pm$ SD Range (min to max)	64.36 $\pm$ 8.28 (51–82)	65.36 $\pm$ 8.66 (51–84)	0.678
Gender:			
Females	17 (56.7%)	17 (56.7%)	1.000
Males	13 (43.3%)	13 (43.3%)	
Affected side:			
Left	17 (56.7%)	17 (56.7%)	1.000
Right	13 (43.3%)	13 (43.3%)	
AO classification:			
31A-2.2	19 (63.3%)	23 (76.7%)	0.489
31A-2.3	6 (20.0%)	4 (13.3%)	
31A-3.1	5 (16.7%)	2 (6.7%)	
31A-3.2	0 (0.0%)	1 (3.3%)	

Table 2

Summary of Operative Details of two groups.

Operative details	PFN (n = 30)	PFNA (n = 30)	p-value (Student's t-test)
Closed Reduction	30 (100%)	30 (100%)	
Surgery Duration (minutes): Mean $\pm$ SD	43.32 $\pm$ 8.20	35.20 $\pm$ 6.03	p < 0.001
Range (min to max)	30 to 60	30 to 50	
Blood loss (ml): Mean $\pm$ SD	77.80 $\pm$ 17.39	59.80 $\pm$ 14.96	p < 0.001
Range (min to max)	60 to 120	40 to 100	
Blood transfusion:			
Yes (1 unit)	10 (33.3%)	7 (23.0%)	0.370
Images (no): Mean $\pm$ SD	29.52 $\pm$ 4.85	18.60 $\pm$ 3.12	p < 0.001
Range (min to max)	24 to 40	15 to 26	

Table 3

Duration of hospital stay and incidence of immediate postoperative complications of two groups.

Postoperative complications	PFN (n = 30)	PFNA (n = 30)	p-value (Student's t-test)
Wound infection:			
No	28 (93.3%)	28 (93.3%)	1.000
Superficial infection	2 (6.7%)	2 (6.7%)	
Thrombo-embolism:			
No	30 (100.0%)	30 (100%)	—
Bed sore:			
No	29 (96.7%)	29 (96.7%)	1.000
Yes	1 (3.3%)	1 (3.3%)	
Hospital stay (days): Mean $\pm$ SD	8.00 $\pm$ 2.89	6.60 $\pm$ 2.35	0.066
Range (min to max)	(6–16)	(5–14)	

two groups are summarized in Table 4. There was neither any periprosthetic fracture (0%) nor any implant breakage (0%) in two groups. The cut out/z-effect and reoperation rates were also similar ($p > 0.05$) between the two groups though both were lowered by 3.4% in helical PFN group as compared to screw PFN group. Further, there was no non-union reported in either of the two groups.

3.5. Anatomical restoration (residual/late deformity)

The anatomical restoration (residual/late deformity), i.e. shortening (>1 cm), varus and external rotation, of two groups are summarized in Table 5. There was no statistically significant difference between both groups in terms of anatomical restoration ($p > 0.05$) though both shortening and varus was lesser (3.4%) in

Table 4

Implant related complications of two groups.

Implant related complications	PFN (n = 30)	PFNA (n = 30)	p-value (Student's t-test)
Periprosthetic fracture	0 (0%)	0 (0%)	—
Implant breakage	0 (0%)	0 (0%)	—
Re-operation	2 (6.7%)	1 (3.3%)	0.552
Non-union	0 (0%)	0 (0%)	—

Table 5

Anatomical restoration of two groups.

Anatomical Restoration	PFN (n = 30)	PFNA (n = 30)	p-value (Student's t-test)
Shortening (>1 cm)			
No	25 (83.3%)	26 (86.7%)	0.684
Yes	5 (16.7%)	4 (13.3%)	
Varus			
No	28 (93.3%)	29 (96.7%)	0.552
Yes	2 (6.7%)	1 (3.3%)	
External rotation			
No	28 (93.33%)	28 (93.3%)	1.000
Yes	2 (6.7%)	2 (6.7%)	

Table 6

Final outcome measures of two groups.

Final outcome measures	PFN (n = 30)	PFNA (n = 30)	P Value (Student's t-test)
Mortality:			
Yes	1 (3.3.0%)	2 (6.7%)	0.552
Persistent pain:			
Yes	5 (16.7%)	4 (13.3%)	0.727
Use of walking aids:			
Yes	11 (36.7%)	8 (26.7%)	0.401
Return to pre fracture:			
Yes	20 (66.7%)	23 (76.7%)	0.374
Harris hip score (at 6 Months)			
Mean $\pm$ SD	86.83 $\pm$ 11.29	88.48 $\pm$ 7.56	0.58
Range (min to max)	(50–95)	(64–95)	

helical PFN group as compared to screw PFN group.

3.6. Final outcome

The final outcome of two groups was measured in terms of mortality, persistent pain, use of walking aids, return to pre-fracture (functional status) and Harris hip score are summarized in Table 6. There was no statistically significant difference ($p > 0.05$) in any of the final outcome measures between the two groups, though helical PFN group fared marginally better. The outcome of each group is illustrated by a representative case from each group shown in Fig. 1 (Screw PFN group) and Fig. 2 (Helical PFN group).

4. Discussion

Trochanteric fractures are a common injury amongst the elderly

due to increased osteoporosis as well as secondary to low energy trauma like falls.²⁵ With increasing life expectancy, the incidence of these fractures is increasing and is likely to double by the year 2050.^{25,26}

Fracture related mortality and morbidity is significantly reduced by early surgical stabilization of the fracture which enables early mobilization and return to pre-fracture activity level which remains the main aim of treatment.²⁷ Elderly patients are highly susceptible to postoperative complications like wound infections, pneumonia, urinary tract infections or cardiovascular events. Above that, due to poor bone quality or osteoporosis the fracture fixation remains a challenging task. For these patients, it is imperative to have an implant, which allows immediate mobilization, full weight bearing and early return to their pre-fracture activity level.²⁸ Unfortunately, the rate of failure of fracture fixation (implant failure) for trochanteric fractures ranges up to 20%.²⁹ This implant failure

Fig. 1. Representative case of unstable trochanteric fracture managed by screw PFN (Serial X-rays- Preoperative to fracture union).

Fig. 2. Representative case of unstable trochanteric fracture managed by helical PFN (Serial X-rays- Preoperative to fracture union).

requires a surgical revision, prolonged hospital stay, increases risk for infections and further diminishes chances for regaining autonomy and mobility.

After the initial debate of preferred choice between cephalo-medullary and extramedullary implants, superiority of cephalo-medullary implants over extramedullary implants in management of unstable trochanteric fractures has gradually been established over the years, in view of high cut-out rates of lag screw from superior part of femoral head in extramedullary fixation devices, i.e. dynamic hip screw.^{30,31} Cephalo-medullary implants have shorter lever arm for the fixation device allowing lower potential for the fracture collapse and limb shortening when used for unstable trochanteric fractures.²¹

Even the cephalo-medullary implants have been evolving over the last two decades. Screw proximal femoral nail was developed by AO/ASIF in 1996 to reduce difficulties faced in earlier intramedullary devices with design features like fluting of nail tip, additional anti-rotation screw and more proximal shifting of distal locking screw to enable gradual change in stiffness of nail construct.³² Helical PFN was introduced in 2003 by AO/ASIF as an improvement over screw PFN with the major improvement being introduction of helical blade which gets better purchase in femoral head bone by radial compaction of the surrounding cancellous bone around the flanges of blade. Biomechanically, helical blade has higher cut-out resistance than screw systems like screw PFN.^{32,33} Center-center position in head of femur of any kind of lag screw or blade is considered ideal to minimize rotation of the head of femur during insertion and to prevent further mechanical complications like a cut-out.³⁴

This study was conducted to compare a second-generation implant (screw PFN) with a third-generation implant (helical PFN) in terms of differences in outcome of treatment based on the hypothesis that the third-generation implants would have better outcomes and fewer complications than the second-generation implants. The results of our study indicate that both screw and helical PFN produce equally reliable results in unstable trochanteric fracture fixation in the elderly. Adequate fracture reduction and optimal position of implants remains a pre-requisite to avoid mechanical failure.

Migration and cutting out were the main problems with both the implants. Although the complication rates of the helical PFN were lower than of the screw PFN, the difference was not statistically significant. The cutting out rate of the screw PFN was 6.7% which seems disappointing, although it is not above the average shown in other studies.^{35,36} In contrast to the screw PFN, complication rates of the third-generation implants were much lower: 3.3% for the helical PFN. Above that, unlike a few other studies, no

ipsilateral femur shaft fracture was observed in either of the patient groups.^{37,38} In our study, shortening of limb by more than 1 cm occurred in 16.7% screw PFN cases and 13.3% in helical PFN which is comparable to other studies.³⁹

A limitation of this study is the relatively short follow up of only 12 months missing late complications like avascular necrosis of femoral head and fracture of shaft of femur at tip of nail. But under normal bone healing conditions and early full-weight bearing mobilization this is the time when the stability provided by implant is most effectively demonstrated. In the old patients, most of the mechanical implant related complications occur within the first 12 weeks.

5. Conclusions

Our study clearly suggests that both screw PFN and helical PFN are equally effective implants in fixation of unstable trochanteric fractures with no significant difference between their short-term complication rates, though helical PFN has marginally lower complication rate and lesser operative time, blood loss and imaging required. A long-term study with a larger sample size will enable full evaluation of performance of helical PFNA as compared to screw PFN.

Conflicts of interest

Nil.

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