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Original Research Article

Comparative study of Ender's nailing and PFN in subtrochanteric fractures of femur in adults

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ABSTRACT

Background: The incidence of proximal femoral fractures are markedly increasing because of increasing life expectancy and motor vehicle accidents. Subtrochanteric fractures of femur pose a great problem because of diversity of fracture patterns and difficulty in attaining anatomical reduction and also it is high stress region, having less vascularity. Intramedullary fixation devices like PFN is technically demanding and many times it needs open reduction of fractures. Favourable mechanics is attained by flexible intramedullary nailing like Ender's nailing.

Materials and Methods: This is a comparative study of 40 cases of subtrochanteric fractures of femur, out of which 20 treated with Ender's nailing and other 20 treated with PFN. All were closed fractures. Age was ranging from 20 to 70 years. In our study patients distribution according to Frank- Seinsheimer classification was as follows… Type I – Nil, II A – 1 pt., II B – 6 pts., II C – 1 pt., III A – 11 pts., III B – 6 pts., IV – 7 pts., V – 8 pts. In PFN open reduction was done in 5 pts., while in Ender's nailing all pts. were managed by close reduction.

Results: Average union time was 18 weeks in PFN, while 15 weeks in Ender's nailing. Reoperation due to implant breakage and/or Z-effect was required in two cases in PFN. Shortening upto 1 cm. seen in 2 pts. in PFN, while in Ender's nailing upto 1 cm. in 6 pts. and from 1 to 2 cm in 2 pts.

Conclusion: In obese pts. Ender's nailing is easy, while PFN is more technically demanding. Union is earlier in Ender's nailing v/s PFN. PFN is more stable implant. Excellent or good results are seen in 15 out of 20 pts. in PFN, while 18 out of 20 pts. in Ender's nailing.

1. Introduction

Subtrochanteric fractures are femoral fractures that extends from lesser trochanter to distally upto 5 cm.[1] The incidence of proximal femoral fractures are markedly increasing because of increasing life expectancy and motor vehicle accidents. Subtrochanteric femoral fracture pose a big difficulty because of diversity of fracture patterns and difficulty in achieving anatomical reduction. In elderly individuals, low energy trauma usually results in multi-fragmentary fractures, sometimes with an unstable configuration.[2]

During routine activities, subtrochanteric region is exposed to high stresses. Axial loading forces through the hip joint produce a large moment arm, with significant medial compressive & lateral tensile stresses. In addition to bending forces, muscle forces at the hip also create torsional effects that lead to significant rotational shear forces. In subtrochanteric region thickness of cortical bone is more and vascularity is less which produces healing problems. High tensile & compressive acts of muscles separate the fracture fragments and cause instability of the fracture. Hence this fracture is tough to manage and is associated with many problems including implant failure, mal-union,

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delayed or non-union.[3]

The most suitable implant for the internal fixation of subtroch. fractures remains a subject of debate, and many intramedullary and extramedullary devices for their surgical fixation have been advocated[4].For a long time, the solution for such fractures was open reduction and internal fixation. Over the past decades, the open reduction technique has changed substantially. Originally, anatomical reduction with rigid internal fixation was desired, entailing too much soft tissue dissection, leaving the fragment avascular. Intramedullary nailing has many advantages, including easy insertion using a closed technique, retaining the fracture haematoma and a lower infection rate due to less surgical dissection. Closed nailing constitutes a form of biological fixation of the femur, which may be credited for a shorter time to union.[2]

Intramedullary fixation devices like PFN[4] is technically demanding, needs perfect entry site and many times it needs open reduction of fracture before inserting nail taking more operative time and increased chance of infection and wash out of fracture haematoma delaying fracture union. It is more rigid type of fixation. Favourable mechanical conditions are obtained following flexible intramedullary nailing like Ender's nailing,[5] because axial forces are distributed along the entire length of the nail and bending moments are minimized. Compression of the fracture fragments occur without excessive stress on the nails, enabling the patient to bear weight on the extremity.[6]

A review of literature fails to demonstrate a large series of comparative study of Ender's nailing and PFN in treatment of subtrochanteric fracture of femur in adults, so I have tried to study that.

2. Materials and Methods

This is a comparative study of 40 cases of subtrochanteric fractures of femur, out of which 20 treated with Ender's nailing and other 20 treated with PFN. All were closed fractures. Age was ranging from 20 to 70 years, average age was 45 yrs. 20-30 yrs.- 6 patients, 30-40 yrs.-12 patients, 40-50 yrs.-9 patients, 50-60 yrs.- 9 patients and 60-70 yrs- 4 patients were there. 30 males and 10 female pts.were there.

Cause of fracture was Road traffic accident in 23 pts., fall from height in 8 pts. and domestic fall in 9 pts. 22 right sided and 18 left sided fractures were there. Pathological fractures, fractures in patients<18 yrs., old neglected fractures, periprosthetic and open fractures were excluded from the study. We followed frank-seinsheimer classification which is based on number of fragments and the location and configuration of fracture lines. In our study patients distribution was as follows : Type I: nil, II-a : 1 pt., II- b: 6 pts., II- c: 1 pt., III-a: 11 pts., III-b : 6 pts., IV : 7 pts., V : 8 pts.

Patients were selected randomly for both modalities of treatment, so distribution of fracture type and age group were almost same in both. After admission, below knee skin traction given. Xrays taken, patient assessed and investigated for medical fitness.

2.1. PFN

The implant consists of a Proximal femoral nail, two proximal screws (8 mm and a 6.5 mm femoral neck screw), two 4.9 mm distal locking screws and an end cap. The proximal diameter of nail is 14 mm. This increases the stability of the implant. The medio-lateral valgus angle is 6*, which prevents varus collapse of the fracture even when there is medial comminution. Proximally, it has two holes: the distal one is for the insertion of a 8 mm neck screw, which acts as a sliding screw and the proximal one is for a 6.5 mm hip pin, which helps prevent rotation. The distal diameter is tapered upto 09 to 12 mm, which also has grooves to prevent stress concentration at the end of the nail. Distally, the nail has two holes for insertion of 4.9 mm locking screws, of which one is static and the other is dynamic allowing dynamization of 5 mm.

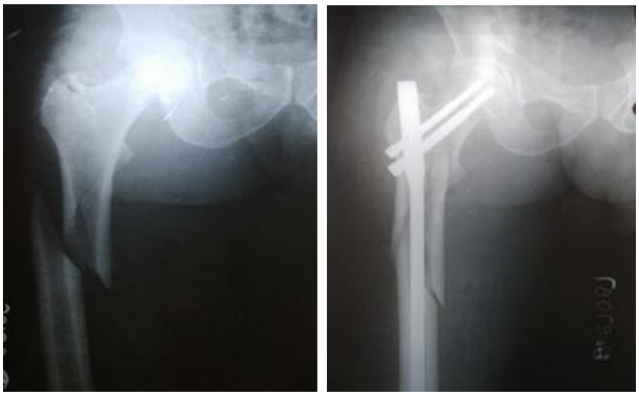

Fig. 1: Pre-ope & Post-ope

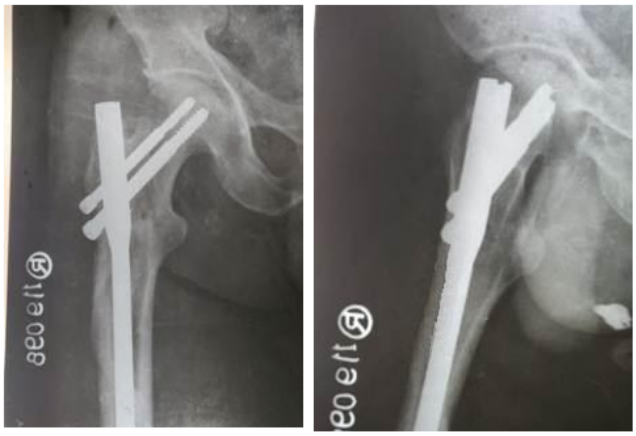

Fig. 2: At 18 weeks follow up

Fig. 3: Clinical pictures at 18 weeks

Fig. 4: Patient positioning in OT

Fig. 5: PFN entry site

The patients were positioned supine on the fracture table in such a way as we can easily visualize the proximal femur in lateral and AP planes. To overcome the difficulty in accessing the tip of trochanter and for unimpeded access to the medullary cavity of the proximal femur, the trunk was abducted at the waist by 10 to 15 degree to opposite side or the affected limb was adducted by 10 to 15 degree.

The tip of greater trochanter palpated and a 5cm longitudinal incision was made proximal to it. Fascia lata and gluteus medius muscles incised and the tip of the greater trochanter exposed. Entry was made from slightly medial to the tip of greater trochanter in AP and in the centre of the medullary cavity in the lateral view. After entry made with a curved bone awl, guide wire inserted into the medullary canal. Open reduction of fracture may be necessary in some cases when closed reduction not possible. Using a cannulated conical reamer, the proximal femur was reamed for a distance of about 7 cm. Reaming of femoral shaft was done when necessary- usually in young pts. After confirming satisfactory fracture reduction, an appropriate size nail was inserted as far as possible into the femoral opening until the hole for 8 mm screw was at the level of lower part of the femoral neck.

For inserting proximal screws, first 2.8 mm guide wires are inserted through the drill sleeve at both holes and checked the position in both AP and lateral view under IITV. 8 mm lag screw should be placed in the lower part of the neck close to the femoral calcar with the screw tip reaching the subchondral bone 5 mm below the articular cartilage in the AP view, and in the center of the femoral neck in the lateral view, thus in the area of best bone quality. Drilling was done over guide wire with appropriate drill bit, and the 6.5 mm anti-rotation screw was inserted first to prevent possible rotation of the medial fragment and to reduce chances of varus angulation when inserting the 8 mm compression screw. Compression screw was placed in same way after drilling. Then distal locking was done with two cortical screws by free hand technique. Closure done.

Appropriate antibiotics and analgesics were given. Static quadriceps and knee mobilization exercises started in the immediate postope. period. On the 3^{rd}-4^{th} postoperative day, depending on the patient's pain tolerance, they were made to stand up with assistance, and gradually over following 2-3 days they were allowed non- weight bearing walking with walker. Partial weight bearing started at four weeks and full weight bearing at 12 weeks in all pts.

2.2. *Ender's nailing*

Under suitable anaesthesia patient is put on orthopaedic table into the supine position with legs well abducted to allow the operator access to the medial side of the knee of the affected limb and to allow the head of IITV to rotate for the lateral x-rays. Close reduction is done and checked in IITV. Minor displacement can be adjusted during the operation either by manual pressure or using nail as lever.

After painting and drapping a longitudinal incision of about 7 cm is made running proximally from the adductor tubercle. After dividing the fascia and separating the vastus medialis from the adductor magnus tendon, the muscles can be held back by Hohman levers and the femoral shaft becomes visible. There is no muscles attachment in this region. The collateral ligament lies distally and only a branch of the medial superior genicular artery and two small veins cross the shaft. These should be cauterized. The

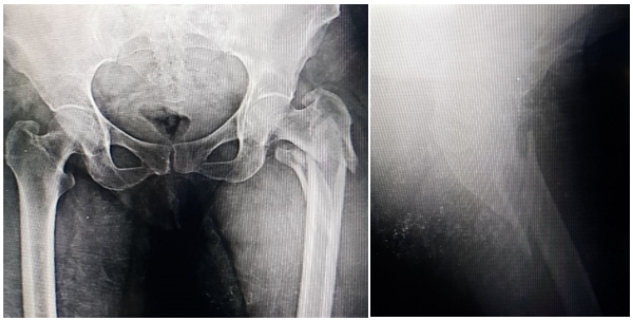

Fig. 6: Pre-ope

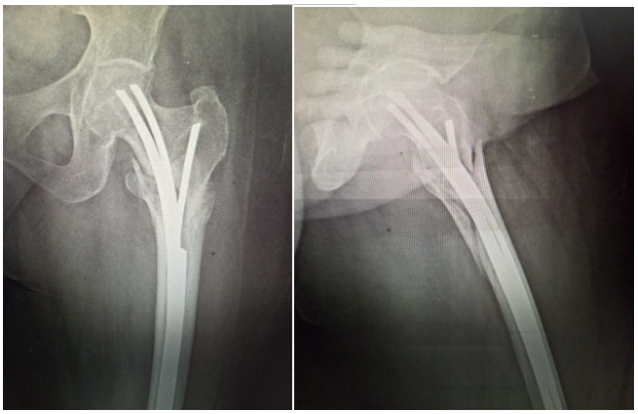

Fig. 7: Post-ope

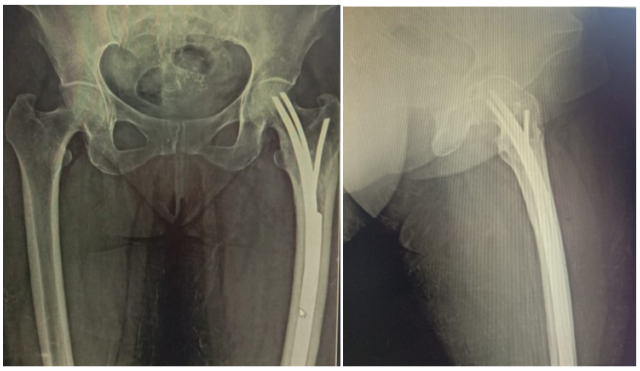

Fig. 8: At 18 weeks follow-up

Fig. 9: Clinical pictures at 18 weeks

Fig. 10: Ender's entry site

medial cortex is now perforated with the help of drill bit at the level just proximal to this vessels and then by awl it is widened to an elliptic hole. The entry should be posterior. The chosen nail is bent as required (at the tip, at middle part – general bend and near distal part – approx. 20* posterior bend) and introduced into the medullary cavity one by one under IITV guidance. Due to posterior bending at distal end the nail more easily follows the natural anteversion of femoral neck, avoiding the tendency to outward rotation of the leg and chipping of bone which can occur at the entry site.[7]

The first nail should be hammered medially along the calcar and into the femoral head. Two or three more nails are then inserted and should be placed so that their proximal tips are arranged in a fan shape in the head. This can be achieved by proper bending of nails and use of rotator. In head and neck of the femur, the nails should fan out in both planes and the tip should lie at 5 to 10 mm of the subchondral region. Minimum of three and preferably four or five nails are inserted. If possible a nail from lateral side is inserted to greater trochanter (or from greater trochanter to downwards). It gives better stability. Proper jamming of the nails into the medullary cavity reduces the back out of nails. After operation the fascia is approximated, skin sutures taken and dressing kept.

The patient is allowed to partially bear weight as early as possible after surgery usually first postoperative day if stability of fixation permits. With wt. bearing impaction at the fracture site will occur. If nail lengths are correctly chosen, they may move downwards for a few mms., but cause no symptoms.

All 40 patients were followed up at 6 weeks, 12 weeks and thereafter at 6 weekly intervals, till fracture union was noted. Patient assessed clinically at every visits for fracture union, hip and knee function, walking ability, deformity and shortening. During follow-up AP and lateral radiographs of hip with proximal femur were obtained.

3. Results

Average blood loss in PFN was 150 cc (more blood loss occurred in open reduction cases) and in Ender's nailing it was 75 cc.

Table 1: Total time taken for surgery

	PFN	Ender's Nailing
Between 30 min. & 1 hr.	5 pt.	11 pt.
Between 1 hr. & 1.5 hr.	11 pt.	8 pt.
More than 1.5 hrs.	4 pt.	1 pt.
Average time	75 min.	55 min.

Implant

Ender's: In all cases 4.5 mm. nails were used. Total 3 nails in 7 cases and total 4 nails in 13 cases were used. In 14 cases nails in lateral to lateral direction going to greater trochanter was inserted along with nails going to heads.

PFN: Two distal locking was done in all cases. We were unable to put proximal anti-rotation screw in one case.

No encirclage wiring done in any cases of Ender's nailing or PFN.

In PFN open reduction was done in 5 patients. While in Ender's nailing all patients were managed by close reduction. Only one superficial infection occurred in PFN, while no infection in Ender's nailing.

Intra ope. Complications

Minimal cortical chip fracture occurred at entry site, in 7 pts. in Ender's nailing. While fracture of lateral cortex of greater trochanter occurred in one pt. in PFN.

Table 2: Union

Time of radiological union	PFN	Ender's nailing
10 to 14 weeks	2 pts.	7 pts.
14 to 20 weeks	13 pts.	12 pts.
More than 20 weeks	5 pts.	1 pt.
Average time	18 weeks	15 weeks

Table 3: Deformity

	PFN	Ender's nailing
Shortening upto 1 cm, 1 cm to 2 cm, More than 2 cm	2 pts., 0 pt., 0 pt.	6 pts., 2 pts., 0 pt.
Valgus> 10*	0 pt.	2 pts.
Varus > 5*	2 pts.	0 pt.
Ext. rotation def.	0 pt.	1 pt. (5* ext. rotation def.)

Table 4: Delayed complications

	PFN	Ender's nailing
Hip jt. Stiffness	1 pt.	0 pt.
Knee jt. Stiffness	1 pt.	1 pt.
Implant failure	1 pt.	0 pt.
Z – effect	2 pts.	-
Reverse Z – effect	0 pt.	-
Ender's nail backed out causing knee problem	-	1 pt.

Table 5: Our results are as follows

	PFN	Ender's nailing
Excellent	7 pts.	8 pts.
Good	8 pts.	10 pts.
Fair	4 pts.	2 pts.
Poor	1 pt,	0 pt.

Criteria of evaluation of final results given in Table 6.

4. Discussion

4.1. PFN

In a minimally open approach, intramedullary nailing nearly works as 'biological internal fixation'. In addition to its mechanical benefits over plate fixation, intramedullary fixation allows the surgeon to minimize soft tissue dissection, thereby reducing surgical trauma, blood loss, infection, and wound complications.[8] Good reduction with minimal dissection, use of appropriate nail length and proper positioning of the nail and screws are necessary to avoid failure or revision. The abundant muscles around the subtrochanteric region usually cause significant displacement of the fractured fragments, leading to great difficulties in close reduction under traction. Sometimes open reduction through a small incision at the fracture site is inevitable. While with Ender's nails, we can manipulate with nails and achieve acceptable close reduction in that cases.

Open reduction was performed in 5 cases out of which 3 were Type IIb fractures, 1 cases each of Type IIIb and Type V fractures. Difficulty in reduction was probably due to the intact lesser trochanter and muscle pull which leads to flexion, abduction and external rotation of proximal fragment in Types IIb and IIIb and due to severe comminution of fracture in Type V fractures. In our study in 2 cases of Type IIb, union was delayed due to inadequate reduction of fracture, for which dynamization was done with fracture union on follow-up in both cases. One case of implant breakage at four months was treated with exchange nailing and the fracture united three months thereafter.

Iatrogenic fracture of lateral cortex of proximal fragment was seen in one case probably due to wrong entry point. In one case failure to place both proximal screws together was seen, hence proximal locking was left with only neck screw (compression screw) thus decreasing stability of construct.

Table 6: Criteria of evaluation of final results

	Union time in weeks	Deformity	Hip movements			Shortening in cms.	Knee movements
			F	ER	Ab		
Excellent	< 18	Nil	Full	Full	Full	Nil	Full
Good	< 18	Nil	120-135	30-45	30-45	Upto 1	Full
Fair	18 to 32	Nil	90-120	15-30	15-30	1 to 2.5	>90
Poor	>32	Present	<90	<15	<15	>2.5	FFD/flex.<90

FFD = Fixed Flexion Deformity, F = Flexion, ER = External rotation in 90* flexion, Ab = Abduction

We have taken this criteria from Indian journal of orthopaedics vol. 18, no. – 1 January 1984 and modified it to some extent.

In our study superficial wound infection was seen in one case in which open reduction was performed, and infection resolved with intravenous antibiotics continued for three weeks.

Various mechanical complications associated with PFN were reported by many authors including Z-effect (cut out of screw), reverse Z-effect, implant failure and failure of fixation requiring re-operation. Werner et al.[9] were the first to introduce the term Z-effect, detected in 7% of their cases. It was described as lateral migration of the inferior screws, varus collapse of the fracture and perforation of the femoral head by superior screw in the postoperative weight bearing period. They concluded that fracture fixation at a cervico-diaphysial angle of <125* was a leading factor for the Z-effect and reverse Z-effect, as well as screw cut-outs. Strauss et al.[10] Have reproduced the migration of the cephalic screws from the intra medullary nail in the laboratory with the aid of a polyurethane model and observed that when compressive forces on the femoral head and bone density were greater than those on the femoral neck, inferior screw migrated laterally. The reverse Z-effect as described by Boldin et al.[11] involves the lateral migration of the superior screw accompanied by the medial migration of the inferior screw, which required early removal. In our study Z-effect was seen in two cases and reverse Z-effect in no cases. Re-operation due to implant breakage and/or Z-effect required in 2 cases in our study.

4.2. Ender's nailing

Biomechanically operative treatment of subtrochanteric fractures with Ender's nails corresponds to the physiological flow of forces of bending, torsion and shearing by its axial position in the field of force and by virtue of its elasticity. Forces are distributed along the entire length of the nail resulting in low incidence of device failure and non-union. The dynamically controlled motion (compressive force) at the fracture site after Ender's nailing is probably responsible for the early appearance of External callus and early bridging of fracture site. Bone grafting of even comminuted fractures is found to be unnecessary because bending and torsional forces are neutralised at the fracture site. In our study average union time was 15 weeks.

In 14 patients out of 20 patients nails in lateral to lateral direction were inserted either from lateral side of lower femoral end going to greater trochanter or from greater trochanter downwards alongwith 2 or 3 nails going to head of the femur. This technique gives better reduction of fracture and better stability. Greater trochanter must be intact for that. When nails are inserted from both medial and lateral sides of the lower femoral end, the entry site should not be at same level but must be at somewhat different level to minimize the chances of supracondylar fracture. Propagation of linear cracks at the insertion site can be prevented by placement of Lawman clamp on the femoral shaft just proximal to the portal site and tightened securely prior to inserting the nails.[12]

To minimize migration and penetration of the nails proximally and distally and early reoperation following things are important[12–14]:- Inserting the nails past ward's triangle into cancellous bone of the femoral head, stacking the femoral canal with nails, splaying the nails within the femoral head, selecting proper size of the nails and subchondral placement of the tip in the femoral head. Knee irritation is usually the result of insertion portals situated too far anteriorly or distally or protrusion of the nails from the portal sites.[12] Ideal nail portals are just proximal to the genicular artery, which runs vertically within the periosteum of the distal femur and also entry should be posterior and posterior bend should be given to the nails. There was only one case of nail backout causing significant knee problem. We removed nails after fracture union in that case.

4.3. Comparison

In obese pts. PFN is difficult but Ender's nailing can be done easily. PFN gives more rotational stability but Ender's nails properly placed (fanning, stacking more nails, subchondral placement, one or two nails in greater trochanter) give enough rotational stability. Minor external rotation deformity in some cases of Ender's nailing can be minimized by use of nails that have anteversion bending and positioning the limb in proper neutral position with help of pillow during immediate post-operative period or use of DRB in severely comminuted cases.

Controlled collapse is more with Ender's nailing as compared to PFN, so more chances of union. Risk of delayed and non-union is greatly reduced in Ender's nailing. In Ender's nailing chances of shortening is more (mainly comminuted cases) which can be minimized by keeping patient NWB for few weeks to prevent excessive collapse at fracture site in comminuted cases. Some valgus that occurs at hip in many cases of Ender's nailing, compensates slight shortening that occurs due to collapse at fracture site. In PFN chances of shortening is very less, but instead delayed or non-union are more in such comminuted cases. Sometimes slight varus occurs in PFN.

Both are minimal invasive technique so less tissue trauma, less blood loss, less chances of infection and less operative time. Both are load sharing implant (Ender's nail more). IITV exposure is more in both. PFN is somewhat technically demanding. Average operative time and average blood loss are more in PFN as compared to Ender's nailing which is also attributed to some cases of open reduction.

5. Conclusion

Average operative time and blood loss are less in Ender's nailing v/s PFN. Open reduction is needed in some cases of PFN. Union is earlier in Ender's nailing v/s PFN. PFN is more stable implant, while chances of slight shortening and external rotation deformity are there with Ender's nailing. Slight chances of varus at fracture site, implant failure and re-operation are there with PFN. While some chances of nail back-out and knee problem are there with Ender's nailing. In obese patients Ender's nailing is easy, while PFN is more technically demanding. In our study excellent and good results are seen in 15 out of 20 patients in PFN, while 18 out of 20 patients in Ender's nailing.

6. Source of Funding

None.

7. Conflict of Interest

The author declares no conflict of interest.

References

1. Bedi A, Toan T. Subtrochanteric femur fractures. *Orthop Clin North Am*. 2004;35(4):473–83.
2. Bucholz RW, Heckman JD, Court-Brown MC. Rockwood and Green's Fractures in Adults. 6th ed. Lippincott Williams & Wilkins; 2006. p. 2–46.
3. Mclaunn TM, Lawler EA. Treatment modalities for subtrochanteric fractures in elderly. Philadelphia: Lippincott Williams and Wilkins Inc; 2004. p. 197–213.
4. Jiang LS, Shen L, Dai LY. Intramedullary fix. of subtroch. fractures with a long proximal femoral nail or a gamma nail: Technical notes and preliminary results. *Ann Acad Med Singapore*. 2007;36:821–6.
5. Ender HG. Treatment of pertrochanteric and subtrochanteric fractures of the femur with Ender's pins. St. Louis: Mosby Year Book Inc; 1978.
6. Fielding JW. Subtrochanteric fractures. *Clin Ortop*. 1973;92:86.
7. Kuderna H, Böhler N, Collon DJ. Treatment of intertrochanteric and subtrochanteric fractures of the hip by the Ender method. *J Bone Joint Surg Am*. 1976;58(5):604–11.
8. Redford PJ, Needoff M, Webb JK. A prospective randomized compa. of the dynamic hip screw & gamma locking nail. *J Bone Joint Surg Br*. 1993;75(5):789–93.
9. Werner-Tutschku W, Lajtai G, Schmiedhuber G, Lang T, Pirkl C, Orthner E. Intra and periope. Compli. in the stabilization of per & subtroch. femur fractures by means of PFN. *Unfallchirurg*. 2002;105(10):881–5.
10. Strauss EJ, Kummer FJ, Koval KJ, Egol KA. The Z-effect phenomenon defined :a lab study. *J Orthop Res*. 2007;25(12):1568–73.
11. Boldin C, Seibert FJ, Frankhauser F, Peicha G, Grechening W, Szyszkowitz R. The proximal femoral nail (PFN)- a minimal invasive treatment of unstable prox. femur fractures: a prospective study of 55 pts. with a follow-up 15 months. *Acta Orthop Scand*. 2003;74(1):53–8.
12. Dobozi WR, Larson BJ, Zindrick M, Davenport K, Hall RF, Whitelaw G. Flexible intramedullary nailing of subtrochanteric fractures of the femur. A multicenter analysis. *Clin Orthop Relat Res*. 1986;212:68–78.
13. Levy RN, Siegel M, Seldin ED, Siffert RS. Complications of Ender Pin fixation in subtrochanteric fractures of the hip. *J Bone Joint Surg Am*. 1983;65(1):66–9.
14. Nestrojil P, Sín A, Bucek P. Pit falls and complications of Weidner-Ender method of osteosynthesis in treatment of fractures of proximal part of femur. *Rozhl Chir*. 1990;69(6):401–6.

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