



Comparison of Intertan Nail Vs. Proximal Femoral Nail in Proximal Femoral Fractures – A Prospective Comparative Study

Sonu Mehta¹, Shoaib Shaikh^{1*}, Sachin Bhonsle¹, Rahul Agrawal¹, Abhinav Bhatnagar¹ and Sameer Rathore²

¹Fortis Hospital, Mulund, Mumbai, India

²KIMS, Hyderabad, India

DOI: 10.5455/jrmds.2017521

ABSTRACT

Incidence of peritrochanteric fractures has increased significantly during recent decades and this tendency will probably continue in the near future due to rising age of the population. Closed methods of treatment have shown higher mortality rates & have largely been abandoned. Rigid internal fixation and early mobilization has been standard method of treatment. This study is intended to compare the results of surgical treatment, to assess and compare the functional and radiological outcomes after proximal femoral fracture fixation using PFN and Intertan nail. Our study included 40 patients having peritrochanteric femur fractures, segregated into two groups (on the basis of the intramedullary device to be used to fix the fracture – Proximal femoral nail and Intertan Nail). Selected parametric values of samples were recorded for the two groups, analyzed and compared for rate of union, complications, and functional outcomes between proximal femoral fracture patients of two groups. Finally, assessment between two groups of treatment was made to identify the significance of effect of either treatment modalities. There were 13 excellent, 5 Good and 2 Fair results in Intertan group with no poor results. In PFN group there were 11 excellent, 5 Good, 3 Fair and 1 poor results. We concluded that Intertan Nail is a good implant for the treatment of peritrochanteric fractures of femur. The results are comparable to AO proximal femoral nail.

Key Words: Proximal femoral nail; peritrochanteric femoral fractures, Intertan nail.

HOW TO CITE THIS ARTICLE: Sonu Mehta, Shoaib Shaikh, Sachin Bhonsle, Rahul Agrawal, Abhinav Bhatnagar and Sameer Rathore, Comparison of Intertan Nail Vs. Proximal Femoral Nail in Proximal Femoral Fractures – A Prospective Comparative Study, J Res Med Dent Sci, 2017, 5 (2):1-9, DOI: 10.5455/jrmds.2017521

Corresponding author: Shoaib Shaikh

e-mail ✉ shoaibsk.7@gmail.com

Received: 12/12/16

Accepted: 25/05/17

INTRODUCTION

Options for surgical management of intertrochanteric and subtrochanteric femur fractures include extra medullary and intramedullary implants. In unstable fracture patterns, intramedullary devices appear to have a biomechanical advantage over extra medullary devices, lowering the forces imposed on the implant due to the shorter lever arm of the fixation [1-2]. Clinical studies have shown that certain intramedullary implant designs can develop complications, such as femoral shaft fracture below the tip of the device, femoral head screw cutout, and collapse at the fracture site [1, 3]. Intramedullary nails with two lag screws were designed to improve rotational

control and bony purchase within the femoral head, thus resisting cutout and subsequent fixation failure [4]. This implant design, however, has led to the recognition of a new failure pattern—the Z-effect phenomenon—which manifests as collapse of the head/neck fragment resulting in protrusion of the superior lag screw and migration of the inferior lag screw lateral to the nail [5-6]. The exact etiology of the differential screw migration has yet to be determined. The proximal femoral nail (PFN) introduced by the AO/ASIF group in 1998 has become prevalent in treating trochanteric fractures in recent years [7]. Although there were several reports showing benefits of proximal femoral nail [8], it was still associated with technical failures [9]. It is an intramedullary device, 3rd generation nail manufactured by Synthes using AO design which has 2 cephalocervical screws and distal locking screw. The TRIGEN INTERTAN nail (Smith & Nephew, Memphis, Tennessee) was recently

introduced, and according to the manufacturer the shape of the nail should enhance stability and offer greater resistance to implant cutout [10]. However, we are not aware of any detailed study comparing the INTERTAN nail with the AO proximal femoral nail. The aim of the present study was to compare the INTERTAN nail with the proximal femoral nail, to determine if use of the nail decreased postoperative pain, improved function, and lowered the post-operative complication rate in patients with a trochanteric or subtrochanteric fracture.

MATERIAL AND METHODS

The study period included 12 months with a six month follow-up of all the patients. The sample size was selected to 40.

Study Parameter

1. Age-sex groups
2. Type of fracture
3. Pain status, rate of union and functional scoring by Harris Hip score
4. Complications

Inclusion Criteria

1. Age > 18 years
2. Both sexes.
3. Patients with intertrochanteric fracture and subtrochanteric fracture not involving the piriformis fossa.
4. Patients with no signs of infection
5. Patients giving consent for surgery

Exclusion Criteria

1. Patients who have undergone previous hip surgery
2. Patients having deformities and pathologies of other joints of the lower limbs having adverse effects on the functional outcome of the surgery.
3. Patients with acute hip infection
4. Patients having associated fractures in other bones which could impede rehabilitation
5. Patients having old proximal femoral fractures which have gone into delayed union, mal union or non-union.

Organization of the Data

Out of total 40 patients, 20 patients were randomly allocated to one group that was treated using intertan nail, while rest 20 patients randomly allocated to another second group treated using proximal femoral nail. Observations on age, sex, affected side, type of fracture, rate of union, complications and functional outcomes in proximal femoral fracture were recorded for each patient for both the treatment modalities.

Statistical Technique

The Pearson's Chi-Square test was used to observe the association of VAS score, rate of union, complications, and functional outcomes in proximal femoral fracture after administration in groups (Intertan and PFN). The probability value, $p > 0.05$ was considered as statistically insignificant but the probability value from $p < 0.06$ to $p < 0.09$ was considered as suggestively or poorly significant. The probability value from $p < 0.05$ to $p < 0.02$ was considered as statistically significant while from $p < 0.01$ to $p < 0.0001$ was considered as statistically highly/strongly significant.

Collection of Data

Upon arrival, the patients were assessed clinically and were stabilized haemodynamically. They were then subjected for radiographs of Pelvis with both hips Antero posterior view and full length thigh Antero posterior view. Following radiographs patients were admitted to orthopaedic wards and were maintained on skin traction Bohler - Braun frame till surgery. Appropriate blood investigations were done and surgical fitness was obtained. All the patients were operated on a fracture table in supine position under image intensifier control using standard techniques. Patients were discharged on the 3rd to 5th post-operative day. Patients were assessed clinically and radiologically on the 2nd post-operative day, at 6 weeks, 3 months and then between 5-6 months. These findings are documented according to a protocol that was developed. Healing was judged by both clinical and radiological criteria and functional outcome was reviewed according to the Harris Hip score (modified).

RESULTS

Out of forty (N=40) proximal femoral fracture patients, approximately two-third (26, 65.0%) of the patients were male and rest (14, 35.0%) were female. The age of all cases (N=40) of proximal femoral fracture was found to be in the ranges from 44 to 79 years had mean (mean \pm SD) age of 59.95 ± 7.69 years. The severity of pain rated on Visual Analogue Scale (VAS) at second day post operation among patients with proximal femoral fracture included in Intertan and PFN groups was noted approximately similar. Non-union was reported in none of the patients of intertan group, while noted in one patient of PFN group. Rate of union was 16 weeks noted in most of (14, 70.0%) patients of Intertan group as compared to most of the (15, 78.9%) patients of PFN group having 18 weeks. Results showed better functional results (Harris

Hip Score) in Intertan group when compared to PFN group. Henceforth, results showed better functional recovery in Intertan group but the differences in functional scoring of patients were not statistically significantly

($p=0.713$). Research showed better results in Intertan group when compared to PFN group as 75.0% patients were found with no complications in comparison to 70.0%.

Table 1: The Frequency and Percentage Distribution of type Of Intertrochantric Fracture According to Boyd & Griffin Classification in Groups

Type of Fracture: Boyd & Griffin classification	Intertan group		PFN group	
	Frequency	Percent (%)	Frequency	Percent (%)
IT TYPE 1	4	20.0	3	15.0
IT TYPE 2	8	40.0	9	45.0
IT TYPE 3	2	10.0	2	10.0
IT TYPE 4	2	10.0	2	10.0
Total	16	100.0	16	100.0

Table 2: the Frequency and Percentage Distribution of Type of Subtrochantric Fracture according To Sensheimer Classification in Groups

Type of Fracture: Sensheimer classification	Intertan group		PFN group	
	Frequency	Percent (%)	Frequency	Percent (%)
Type I	0	0.0	0	0.0
Type II	2	10.0	2	10.0
Type III A	2	10.0	2	10.0
Type IV	0	0.0	0	0.0
Type V	0	0.0	0	0.0
Total	4	100.0	4	100.0

Table 3 : Association of Pain Status of Patients at Post-Intervention with Groups

VAS Score	Intertan group	PFN group	Total
	No. of cases Percentage	No. of cases Percentage	
3	1 5.0%	2 10.0%	3 7.5%
4	9 45.0%	8 40.0%	17 42.5%
5	7 35.0%	6 30.0%	13 32.5%
6	3 15.0%	4 20.0%	7 17.5%
Total	20 100.0%	20 100.0%	40 100.0%

$\chi^2_3 = 0.61$ and $p=0.894$ (Insignificant)

Table 4: Association of Rate of Union among Patients at Post-Intervention with Groups

Rate of Union	Intertan group	PFN group	Total
	No. of cases Percentage	No. of cases Percentage	
16 weeks	14 70.0%	0 0.0%	14 35.9%
18 weeks	0 0.0%	15 78.9%	15 38.5%
20 weeks	6 30.0%	0 0.0%	6 15.4%
22 weeks	0 0.0%	4 21.1%	4 10.3%
Total	20 100.0%	19 100.0%	39 100.0%

$\chi^2_3 = 39.00$ and $p=0.000$ (Highly significant)

Table 5:-Association of Functional Scoring With Harris Hip Score at Post- Intervention with Groups

Functional scoring with Category		Intertan group	PFN group	Total
		No. of cases Percentage	No. of cases Percentage	
<70	Poor	0	1	1
		0.0%	5.0%	2.5%
70-80	Fair	2	3	5
		10.0%	15.0%	12.5%
80-90	Good	5	5	10
		25.0%	25.0%	25.0%
90-100	Excellent	13	11	24
		65.0%	55.0%	60.0%
Total		20	20	40
		100.0%	100.0%	100.0%

$\chi^2_3 = 1.37$ and $p = 0.713$ (Insignificant)

Table 6:- Association of Intraoperative and Post-Operative Complications of Patients with Groups

Complications	Intertan group	PFN group	Total
	No. of cases Percentage	No. of cases Percentage	
None	15	14	29
	75.0%	70.0%	72.5%
Fracture of lateral cortex	1	1	2
	5.0%	5.0%	5.0%
Fracture displacement at nail insertion/Lateral greater trochanteric fracture	2	1	3
	10.0%	5.0%	7.5%
Cut out proximal screws	0	1	1
	0.0%	5.0%	2.5%
Varus mal-union, shortening 2cm	2	1	3
	10.0%	5.0%	7.5%
Z effect	0	1	1
	0.0%	5.0%	2.5%
Non union	0	1	1
	0.0%	5.0%	2.5%
Total	20	20	40
	100.0%	100.0%	100.0%

$\chi^2_6 = 3.70$ and $p = 0.717$ (Insignificant)

DISCUSSION

The treatment of peritrochanteric fracture is still associated with some failures. High stress concentration that is subject to multiple deforming forces, high incidence of complications reported after surgical treatment, compels the surgeon to give a second thought regarding selection of proper implant. To our knowledge, this is the first prospective study directly comparing the intertan nail with proximal femoral nail.

PFN: AO/ASIF introduced a third generation intramedullary device called Proximal Femoral Nail [5],[11]. It also works on principal of controlled collapse at fracture site but being intramedullary it has short lever arm, placed closed to the mechanical axis of femur so it is a load sharing device [11-12]. The advantages of this device are less soft tissue dissection required. Addition of 6.4 mm antirotation screw

is to reduce rotation of cephalocervical fragment [7],[11].

Well documented complications include varus fixation, screw cutout, z effect, reverse z effect, fractures, nonunion, implant related problems such as inability to put in antirotation screw. [5] Intertan Nail: The TRIGEN INTERTAN nail (Smith & Nephew, Memphis, Tennessee) was recently introduced, and according to the manufacturer the shape of the nail should enhance stability and offer greater resistance to implant cutout. Interlocking head screws could prevent z effect and provide compression at fracture site, slits at the end of the nail could prevent postoperative femur shaft fractures [13]. The Intertan system has become increasingly popular with the development of innovative systems, which minimize incidence of fractures of distal femur and increases stability [14]. Nonetheless, there are still some defects in the intertan system such as higher costs and need of operative skills.

Overall, we found comparable results between patients treated with the intertan nail and those treated with PFN. Both groups had similar pain scales at the time of early postoperative mobilization. No significant differences in pain, function, quality of life, or complication rates were evident at three or six months postoperatively. This is in conformity to recent studies and meta-analyses [1],[15]. Butler *et al* [15] conducted an extensive analysis of the Cochrane database, Medline, Scirus, which included 41 articles on intertrochanteric and subtrochanteric fractures indicated that age, sex, prefracture functioning, and cognitive impairment are related to mortality and functional outcomes. Fracture type does not appear to be independently related to patient outcomes. Mortality, pain, function, and quality of life did not differ by surgical implant class, or by implants within a class.

Since the introduction of nailing for intertrochanteric fractures, peri-implant femoral fractures have been well-known complications. According to Bhandari *et al.* [16] this should no longer be an issue with modern nail designs and more experience; however, the authors of a Cochrane review [17] came to a different conclusion. Parker *et al.* [17] searched the Cochrane database, Medline, Embase and other sources, assessed all randomised and quasi randomised control trials comparing cephalocondylar nails and extramedullary implants and concluded that Gamma nail was associated with increased risk of operative and later fracture of the femur, and increased reoperation rate. Fracture fixation complications were more common in the intramedullary implants. There were no major differences between implants in wound infection, mortality or medical complications. Hence, they believe that extramedullary implants like DHS are superior to intramedullary implants based on the above, but in light of recent design related changes in intramedullary implants, they concur that further studies might be needed to assess if the complication rates are lowered. In our study, no postoperative femoral fractures occurred in both the groups which is indeed a promising sign keeping the results of the above study in mind and points towards lowered complication rates in intramedullary implants with better design. In another recent study using intertan nails, 2 intraoperative and 5 postoperative femoral fractures were reported [10]. This implies that this problem with fractures around the tips of intramedullary nails may still persist

but probably due to proper size of the nail or due to smaller sample size in our study, was not encountered. Still more extensive studies may be needed to shed more light on the problem and come to a conclusion. Intraoperative lateral cortex fractures and displacement of fracture fragments or displacement fracture of greater trochanter did however occur in 1 and 2 cases respectively in PFN and intertan group. Probable cause could be due to high profile of instruments, trapezoidal anatomy of nail, or patient related factors such as osteoporotic bone.

Cutting out is a familiar problem in the osteosynthesis of trochanteric femoral fractures. Cut-out rates, including the Z effect, have been reported to range from 3% to 10% with the gamma nail [6],[18],[19]. In study of Vaquero *et al* [20], they found no statistical difference in the cut-out rates between the proximal femoral nail antirotation (PFNA) and the Gamma nail. They believed that cut-out appeared to result from poor positioning of the screw rather than being implant-related and the key to less cut-out was to make sure the proper position of the screw and the correct tip-to-apex distance. However, no significant difference in position of implant and reduction results were shown in our study, but better result was demonstrated in cut-out of the intertan group. In addition, there was a tendency for more intertan patients to return to full weight bearing.

In a prospective study on patients treated with the intertan nail, Ruecker *et al.* [13] reported two implant cut outs in forty-eight patients with one year of follow up. In PFN implant cut out has been extensively documented [5, 21]. The cut out rates for PFN have been documented between 0.6-8% [7, 22]. In our study no cases of implant cut outs were seen in intertan group and only one case was seen in pfn group. As per our experience proper placement of hip screws and preventing early full weight bearing lead to decrease in these well-established complications. It has been a well-known fact that implant positioning and proper surgical technique play a more pivotal role in eliminating this problem rather than the implant itself. Our results may suggest that the design of the implant also plays some role in preventing cut out. Unstable intertrochanteric fractures of femur treated with an intramedullary device are commonly related to mild pain at the site of the fracture and in the middle thigh. Several studies have reported incidences of secondary femoral shaft fractures (up to 17%) due to anterior

cortical impingement of the nail tip and distal locking bolt problems when a short intramedullary device is used. Ruecker *et al.* encountered no nail impingement or thigh pain problems in patients treated for an intertrochanteric fracture using this nail [13]. Although both groups in this study demonstrated no femoral shaft fractures in the post-operative period, the diameter of the intertan nail tapers from 13.5 mm in the middle to 11 mm at the tip, which has a stress dispersion effect on the nail and inner cortex and avoids stress overconcentration around the nail tip. This nail has a split distal tip that reduces overall cross sectional stiffness of the distal implant. This might give the nail an added advantage.

Post operatively the neck shaft angle was measured and compared to the normal side to assess the correction achieved. Varus deformity was noted in two cases in intertan group and one case in PFN group. It might be seen due to inadequate reduction and failure to maintain neck shaft angle preoperatively or due to early backing out of screws. No non unions were reported in intertan group and only one in PFN group. Preoperative planning, implant size selection & optimal placement of implant i.e. placement of proximal screws in central & inferior quadrant of femoral head confirmed on AP & Lateral views are some of the probable important things which minimizes the complications. Fracture healing was assessed on clinical & radiological evidence of fracture union. Average fracture union was 17 weeks in intertan group and 19 weeks in PFN group. The difference is statistically significant. Our estimate for early union in intertan nail could be the rack and pinion design of the intertan nail which allows for fracture compression and correction of any fallacies in reduction. Similar union rates and times have been observed in other studies. Min *et al.* [23] studied reverse oblique fracture patterns and treated them with PFN or gamma nail and observed bone union time as averaging between 16.5 weeks in PFN group and 17.9 weeks in gamma nail group. In all patients follow up was made for minimum period of 6 months & there was no loss in follow up.

Functional outcome was assessed using the modified harris hip scoring system. Good to

Excellent results were seen in 18/20 cases in intertan group as compared to 16/20 cases in PFN group. In a similar study between intertan nail and PFN antirotation for treatment of unstable intertrochanteric fractures, done by Weiguang Yu *et al.* [24] difference between harris hip scores was found to be statistically insignificant between the groups, like in our study. All studies have shown significant improvement in post-operative harris hip scores compared to preoperative but insignificant differences between the 2 study groups. Uncontrolled collapse can be prevented by anti-rotation of the head and neck of the femur. It is reported that the collapse can lead to neck malunion or unacceptable shortening of the head and neck segments. Excessive shortening of the neck (>5 mm) may result in weakened strength of gluteus medius and limit the movement of the hip joint. To avoid shortening, the key point is to have the fracture reduced during the entire process from guidewire insertion through reaming, nail insertion, and locking. The Intertan device, with a hybrid worm-gear mechanism converting rotational forces into linear compression, can overcome the shortening, which may be one of the main reasons why healing time is shorter in intertan group. Although 2 cases in intertan group did show shortening as compared to one case in PFN group and likewise varus collapse, however, no significant differences existed between the two groups regarding lateral migration of the hip screw, implant failure, and final functional outcomes. The mainstay change in the intertan implant is interlocking screws in the head to prevent z and reverse z effect. We did not observe any case of z effect or reverse z effect in intertan group but this effect was noted in PFN group, however in just 1 case. This may arise due to the poor bone density of the femoral head which limited screw purchase and reflects one of the many problems associated with fixation in elderly, osteoporotic bone. Migration of interlocking screws occurs within the nail as these do not secure rigidly within the device itself and is described in the literature as "Z" effect (Proximal migration of the proximal screw) and the "Reversed Z" effect (Distal migration of the proximal screw) [16-17]. The sample size taken in this study was small but we can largely conclude that the intertan nail did prevent z effect, however still important is the proper placement of implant.

Fig. 1 : Intertan Nailing

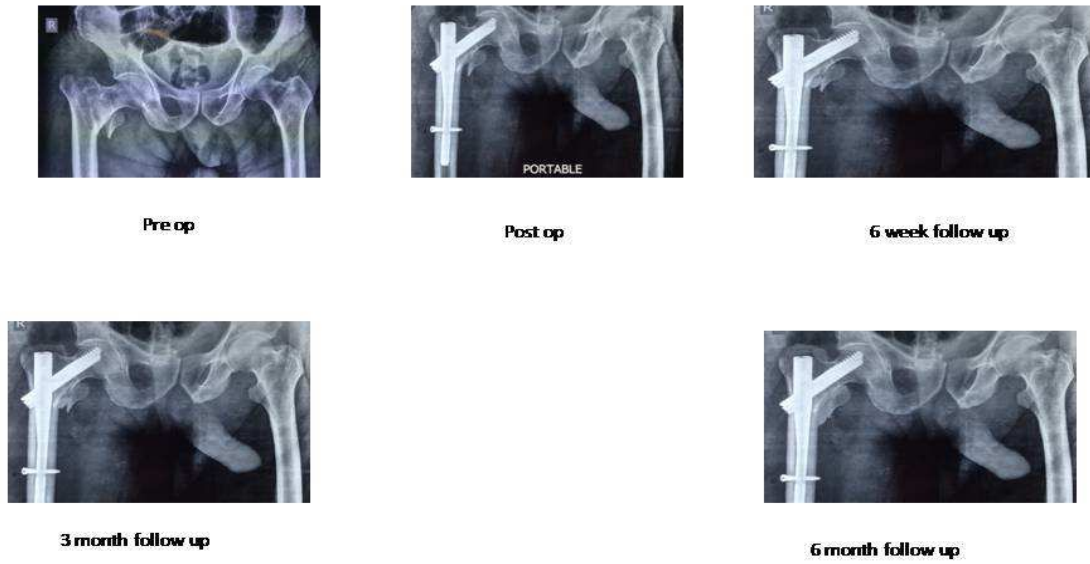


Fig2 : Proximal Femoral Nail



This study had some limitations that warrant consideration. The number of patients was too small to allow comprehensive evaluation of the usefulness or the incidences of complications, and thus, we suggest that a large prospective study be undertaken to compare this type of nail with other fixation devices in these respects. This may also affect statistical analysis. The follow-up was relatively short term. Long-term effect of the two surgical managements was difficult to ascertain.

CONCLUSION

The incidence of intertrochanteric and subtrochanteric fractures of the femur is on the rise because of fast and high speed automobiles and modern lifestyles and increased life expectancy of the elderly age group patients. The deforming forces, high mechanical stresses and morbidity of the fractures in this region have always challenged the ingenuity and skills of the orthopaedic surgeon. Various devices have evolved in an attempt to effectively neutralize these forces. Closed insertion technique, shorter lever arm decreasing the tensile strain on the implant and increased purchase of the proximal fragment are the added advantages of Cephalomedullary nails over other fixation devices in subtrochanteric fractures. This study was conducted to analyze the results of proximal femoral fractures treated with Intertan nail (Smith-Nephew) and compare its outcomes with standard AO proximal femoral nail.

In our series of 20 cases of peritrochanteric fractures treated with Intertan Nail, 18 patients had Excellent to good outcome at their final follow up. Poor outcome was not seen. 2 cases had varus union and 3 patients had displacement of fracture or split of greater trochanteric, none of which required any resurgery. The mean Harris Hip score at their final follow up was 87.5 which is comparable to international publications in the literature.

From this sample study, we conclude that Intertan Nail is a good implant for the treatment of intertrochanteric and subtrochanteric fractures of femur provided optimal reduction of the fracture and good positioning of the nail and screws are achieved. The results are comparable to AO proximal femoral nail.

Acknowledgement:

We thank Dr Sachin Bhonsle, our professor and head of unit of Orthopaedics, for guidance in the surgical technique, and helping us to improvise on the manuscript.

Authors contribution:

Dr Sonu Mehta: Selection of patients and operating and assisting in surgeries.

Dr Shoaib Shaikh: Selection of patients and operating and assisting in surgeries.

Dr Sachin Bhonsle: Head of unit and main operating surgeon.

Dr Rahul Agrawal: Compilation of data and statistics.

Dr Abhinav Bhatnagar: Compilation of data and editing the manuscript.

Conflict of interest: None

REFERENCES

1. Papisimos S, Koutsojannis CM, Panagopoulos A, Megas P, Lambiris E. A randomised comparison of AMBI, TGN and PFN for treatment of unstable trochanteric fractures. *Archives of Orthopaedic and Trauma Surgery*. 2005 ; 125(7): 462-68.
2. Haynes RC, Pöll RG, Miles AW, Weston RB. Failure of femoral head fixation: a cadaveric analysis of lag screw cut-out with the gamma locking nail and AO dynamic hip screw. *Injury*. 1997; 28(5-6): 337-41.
3. Butt MS, Krikler SJ, Nafie S, Ali MS. Comparison of dynamic hip screw and gamma nail: a prospective, randomized, controlled trial. *Injury*. 1995 ; 26(9): 615-18.
4. Kubiak EN, Bong M, Park SS, Kummer F, Egol K, Koval KJ. Intramedullary fixation of unstable intertrochanteric hip fractures: one or two lag screws. *Journal of orthopaedic trauma*. 2004; 18(1): 12-17.
5. Boldin C, Seibert FJ, Fankhauser F, Peicha G, Grechenig W, Szyszkowitz R. The proximal femoral nail (PFN)-a minimal invasive treatment of unstable proximal femoral fractures: a prospective study of 55 patients with a follow-up of 15 months. *Acta Orthopaedica Scandinavica*. 2003; 74(1): 53-58.
6. Tyllianakis M, Panagopoulos A, Papadopoulos A, Papisimos S, Mousafir K. Treatment of extracapsular hip fractures with the proximal femoral nail (PFN): long term results in 45 patients. *Acta orthopaedica belgica*. 2004; 70(5): 444-54.
7. Al-Yassari G, Langstaff RJ, Jones JW, Al-Lami M. The AO/ASIF proximal femoral nail (PFN) for

- the treatment of unstable trochanteric femoral fracture. *Injury*. 2002 ;33(5):395-99.
8. Huang ZY, Liu XW, Su JC. Dynamic hip screw vs. proximal femur nail in treatment of intertrochanteric fractures in patients aged over 70 years old. *Shanghai Medical Journal*. 2010; 33(11): 1042.
 9. Pavelka T, Matejka J, Cervenkova H. Complications of internal fixation by a short proximal femoral nail. *Acta chirurgiae orthopaedicae et traumatologiae Cechoslovaca*. 2005; 72(6): 344-54.
 10. Matre K, Vinje T, Havelin LI, Gjertsen JE, Furnes O, Espehaug B, Kjellevoid SH, Fevang JM. TRIGEN INTERTAN intramedullary nail versus sliding hip screw: a prospective, randomized multicenter study on pain, function, and complications in 684 patients with an intertrochanteric or subtrochanteric fracture and one year of follow-up. *JBJS*. 2013; 95(3): 200-08.
 11. Gadegone WM, Salphale YS. Proximal femoral nail—an analysis of 100 cases of proximal femoral fractures with an average follow up of 1 year. *International orthopaedics*. 2007; 31(3): 403-08.
 12. Brumback RJ, Uwagie-Ero S, Lakatos RP, Poka A, Bathon GH, Burgess AR. Intramedullary nailing of femoral shaft fractures. Part II: Fracture-healing with static interlocking fixation. *The Journal of Bone and Joint Surgery (Am)*. 1988; 70 (10): 1453-62.
 13. Ruecker AH, Rupperecht M, Gruber M, Gebauer M, Barvencik F, Briem D, Rueger JM. The treatment of intertrochanteric fractures: results using an intramedullary nail with integrated cephalocervical screws and linear compression. *Journal of orthopaedic trauma*. 2009; 23(1): 22-30.
 14. Qin H, An Z. Therapeutic evaluation of femoral intertrochanteric fractures by InterTan. *Zhongguo xiu fu chong jian wai ke za zhi= Zhongguo xiufu chongjian waikē zazhi= Chinese journal of reparative and reconstructive surgery*. 2010; 24(12): 1424-27.
 15. Butler M, Forte ML, Joglekar SB, Swiontkowski MF, Kane RL. Evidence summary: systematic review of surgical treatments for geriatric hip fractures. *The Journal of bone and joint surgery*. 2011; 93(12): 1104-15.
 16. Bhandari M, Schemitsch E, Jönsson A, Zlowodzki M, Haidukewych GJ. Gamma nails revisited: gamma nails versus compression hip screws in the management of intertrochanteric fractures of the hip: a meta-analysis. *Journal of orthopaedic trauma*. 2009; 23(6): 460-64.
 17. Parker MJ, Handoll HH. Gamma and other cephalocondylic intramedullary nails versus extramedullary implants for extracapsular hip fractures in adults. *The Cochrane Library*. 2010 Sep 8.
 18. DOI: 10.1002/14651858.CD000093.pub5
 19. Albareda J, Laderiga A, Palanca D, Paniagua L, Seral F. Complications and technical problems with the gamma nail. *International orthopaedics*. 1996; 20(1): 47-50.
 20. Parker MJ, Pryor GA. Gamma versus DHS nailing for extracapsular femoral fractures. *International orthopaedics*. 1996; 20(3): 163-68.
 21. Vaquero J, Munoz J, Prat S, Ramirez C, Aguado HJ, Moreno E, Perez MD. Proximal Femoral Nail Antirotation versus Gamma3 nail for intramedullary nailing of unstable trochanteric fractures. A randomised comparative study. *Injury*. 2012; 43: S47-54. doi: 10.1016/S0020-1383(13)70179-7.
 22. Ballal MS, Emms N, Ramakrishnan M, Thomas G. Proximal femoral nail failures in extracapsular fractures of the hip. *Journal of Orthopaedic Surgery*. 2008; 16(2): 146-49.
 23. Simmermacher RK, Bosch AM, Van der Werken CH. The AO/ASIF-proximal femoral nail (PFN): a new device for the treatment of unstable proximal femoral fractures. *Injury*. 1999; 30(5): 327-32.
 24. Min WK, Kim SY, Kim TK, Lee KB, Cho MR, Ha YC, Koo KH. Proximal femoral nail for the treatment of reverse obliquity intertrochanteric fractures compared with gamma nail. *Journal of Trauma and Acute Care Surgery*. 2007; 63(5): 1054-60.
 25. Yu W, Zhang X, Zhu X, Hu J, Liu Y. A retrospective analysis of the InterTan nail and proximal femoral nail anti-rotation-Asia in the treatment of unstable intertrochanteric femur fractures in the elderly. *Journal of orthopaedic surgery and research*. 2016; 11(1): 10.