International Journal of
Science Inventions Today
www.ijsit.com
ISSN 2319-5436
Review Article

COMPARISON OF INTRAMEDULLARY NAILS IN THE TREATMENT OF INTERTROCHANTERIC FRACTURE - A REVIEW

Manish Pradhananga[1*], Jiang tao Liu[1] and Elsa Rajan Pradhananga[2]

[1]*Department of Orthopaedic Surgery, Xiangyang No.1 People's Hospital, Affiliated to Hubei University of Medicine, Xiangyang, Hubei, China*

[2]*Department of Dermatology, Xiangyang No.1 People's Hospital Affiliated to Hubei University of Medicine, Xiangyang, Hubei, China*

ABSTRACT

Intertrochanteric fractures account for more than half of the fractures around the hip. Intramedullary nail is the standard surgical treatment options chosen by most surgeons and wide variety of implants have been developed for intramedullary fixation. New and modified nails have been introduced as the nails introduced earlier resulted in various complications and poor outcomes compared to extramedullary devices. Many comparative studies have been performed to evaluate the outcomes and superiority of the devices. InterTan, PFNA and Gamma3 are new generation devices, reported to be some of the best devices according to current studies. In this literature review, I reviewed various intramedullary fixation devices, its biomechanical advantages, outcomes and complications. Among these, InterTan nail is suggested to be the optimal device for the fixation of intertrochanteric femoral fractures since it is more stable, showed lesser complications and better performance when compared to other intramedullary nails. However, more comparative studies comparing InterTan with other devices may be required to study more potential advantages to establish its superiority.

Key words: Inertrochanteric fracture; Intramedullary nail; InterTan; PFNA; Gamma3

INTRODUCTION

Intertrochanteric (IT) femoral fractures, is the fracture between the greater trochanter and lesser trochanter. It's a very common fracture accounting for 3 to 4% of all the fractures in the body and more than 50% of proximal femoral fractures. It is common among patients with osteoporosis and occurs in the elderly population with a male to female incidence rate of 1: 2 - 1: 3 [1]. The incidence of IT fractures has increased significantly and is expected to double in the next 25 years as the aged population increases. IT fractures cause significant impact on morbidity, disability and mortality. An overall mortality of 6.3 to 33% has been reported, with men's mortality rate double that of women's [2]. If these fractures are not treated actively, they are prone to nonunion, malunion, avascular necrosis of the femoral head, etc. and severely impaired limb function.

Conservative treatment with sustained bone traction makes the fracture more prone to nonunion, mal-union, varus deformity, cause joint stiffness and make patients bedridden for long. Also the rate of complications like deep vein thrombosis, bed sores, urinary infection, cardiac and pulmonary complication and others, are higher [3].Studies have shown that the total mortality rate is more than 50% in patients managed with conservative treatment [4]. Therefore, surgical management should be the gold standard for all cases except those contraindicated for surgeries. Surgical treatments mainly include hemi- or total hip arthroplasty, extramedullary fixation, intramedullary fixation, and external fixations. Joint replacement, including hemi- or total hip arthroplasty for IT fractures are usually preferred in managing fracture associated with femoral head necrosis and implant failure. For acute fractures, surgical fracture fixation techniques are widely used in clinical practice.

The surgical fixtures used in managing IT fractures can be broadly classified into extramedullary and intramedullary devices. Some of the commonly used extramedullary fixtures are AO / ASIF angle plate, Dynamic Hip Screw (DHS), Proximal femur compression plate (PFCP), Percutaneous compression plate (PCCP) and Locking compression plate (LCP) and the commonly used intramedullary fixations are Ender nail, ACE trochanteric nail, Gamma nailing system, Proximal femoral nail (PFN), Proximal femoral nail antirotation (PFNA), Reconstruction Interlocking Nails, InterTan nail etc. However intramedullary devices are reported to have certain biomechanical advantages and produce good results when compared to extramedullary devices since they give a more rigid fixation [5], require a smaller length of incision, shorter duration of operation and lead to lesser blood loss [6]. These devices are especially suitable for elderly patients with osteoporosis and unstable fractures. This study reviews intramedullary devices for IT femoral fractures.

LITERATURE REVIEW

Gamma Nails:

Since its introduction in 1988 Gamma nail became an indispensable tool in treating unstable IT fracture. The adequate stability and the strength the implant provided to overcome the massive tensile forces

laterally and compressive forces medially made Gamma Nails the most used intramedullary device for many years.

Gamma nail (first generation) Vs Dynamic hip screw:

O'Brien Peter J et al studied 45 cases treated with Gamma nail (GN) and 53 cases treated with Dynamic hip screw (DHS) and found no significant difference between the two groups with respect to intraoperative blood loss, hospital stay, time of union and eventful functional outcome. However they reported 5 cases of varus collapse, 2 cut-out and 1 femoral shaft fracture in the GN group and 3 cases of varus collapse in the DHS group; thereby indicating that GN is not superior to DHS [7]. Another comparative study of GN and DHS reported no significant difference in operative time, blood loss, wound complications, length of hospital stay and patient mobility at final review. Intraoperative complications were more common with the GN where 11 out of the 105 cases had malalignment and 1 had post-operative femoral shaft fracture compared to DHS where only 14 out of the 157 cases had malalignment[8]. The intraoperative complications could presumably be due to the learning curve associated with becoming familiar with the implant [8]. Saarenpää et al in their prospective match-pair study reported that the frequency of reoperations was 8.2% among patients managed with DHS and 12.7% in those treated with GN. Periprosthetic fracture rate of the femoral shaft was reported to be 1.5% following fixation with GN [9].

The commonest complication related to GN device is fracture shaft of femur at the distal tip of the implant. Secondary rotation of the head–neck fragment followed by collapse at the fracture site and cut-out represent characteristic device-related adverse events. Authors who were of the opinion that these complications may be due to the design and geometry of the nail and inadequate placement of the distal locking screws suggested modifications to the intramedullary nail design to minimize mechanical complications. With the advent of advanced implants few comparative studies favoured GN, paving way for modified devices that could overcome these complications and gain favourable outcomes.

The second generation Gamma nail introduced in 1997reported fewer periprosthetic fractures compared to its predecessor owing to its modification. Proximal diameter of the nail was reduced to 16.5mm, proximal lag screw diameter was reduced to 10 mm, valgus angle was reduced to 4^0, and distal static locking screw was changed to 5 mm. Gamma 3, the third-generation gamma nail, introduced in 2003 is made of a nitrogen-containing stainless steel alloy or titanium alloy and has a 17-mm proximal diameter, 180-mm length and 4° valgus curvature, a single transverse distal locking screw and a 10.5-mm diameter lag screw.

Comparison between Gamma nails:

A study by Bojan AJ et al reported fewer periprosthetic femoral shaft fractures in second generation trochanteric gamma nail (TGN) when compared to standard Gamma nail (SGN) [10]. Although the complications with second generation Gamma nail fixation was less compared to SGN (first generation),

desirable results were not found and same complications were persisting. Hence the device was further modified. R. Schupfner et al. compared cases treated with 117 TGN and 100 Gamma3 nails. Rate of complications related to the surgery was cumulatively higher in the TGN group compared to the Gamma3 nail group (13.68% *vs.* 8%).[11]Dimitrios Georgiannos et al. in their study found7.41% postoperative complications in Gamma3 group and 15.62% in TGN group. The most frequent complication in both groups was the cut-out of the lag screw, 4 in Gamma3 and 13 in TGN. The rate of reoperation after implant related complication with the G3N was 5.11% and with TGN was11.45%[11]. In a comparative study by R. Pascarella et al where all three generations of gamma nails were compared, 525 cases were of SGN, 422 were of TGN and 1197 were of Gamma3 Nail. The study reported an overall incidence of 1.21% intra-operative complications with 1.71%, 0.47% and 1.25% incidence of intra-operative complications for SGN, TGN and Gamma3 Nail groups respectively. And the overall incidence of postoperative complications was 5.48 % with 10.73%, 9.92% and 2.92% postoperative complications SGN, TGN and Gamma3 Nail groups respectively. Cut-out was observed in 2.92 % of SGN group, 4.58 % of TGN group and 1.02 % of Gamma3 group [12].

A significant fall in the rate of complication and improvement in biomechanical characteristics are noted inGamma3, proving that it is superior regarding complications, safety and efficiency for treatment of trochanteric fracture. Literature reports 0% to 1.4% incidence of gamma 3 nails related periprostethetic fractures and 0.01% to 1.25% incidence of cut-out [13, 14]. Because of these favourable results, the Gamma3 nail has become a powerful minimally invasive and safe implant for the treatment of IT femoral fractures.

ACE Nail:

The Ace nail introduced in 2001, is a 180mm or 200mm long implant made of titanium alloy that has a 16-mm proximal diameter, 5° valgus curvature and 10.5mm diameter lag-screw with an optional anti-rotation lag-screw and two distal holes for static or dynamic locking.

ACE nail versus Gamma nails:

Philip Winnock de Grave et al in their study of 61 patients using Gamma3 and 51 patients using ACE nail, found two failures occurred in each, the Gamma 3 group (3.2%) and the ACE group (3.9%) which was due to screw cut-out or secondary displacement of the fracture components and underwent revision surgery. They found no significant differences in functional outcome or complication and failure rate [15]. Similarly, Nicolas E. Efstathopoulos et al's study published in 2007 that compared second generation Gamma nail with ACE nail showed no mechanical failure, no intraoperative complications and no significant difference in functional outcome [16]. Another study by Vidyadhara S. et al. compared 37 Gamma nail and 36 ACE nail group and found no significant difference in intra-operative complications and clinical outcome. However, there were three technically difficult lag screw insertions resulting in bent guide wire and drill breakage in one patient treated with ACE nail [17].

In the above mentioned studies ACE nail was compared with different generations gamma nail and the results were similar. However, so far very few trials have been performed in this regard and most of these compared small groups of patients treated using different nails resulting in the lack of a clinically significant difference in the outcome (functional score, mortality, fracture fixation complications and re-operations) between the ACE trochanteric nails and Gamma nails; thereby raising the requirement of most studies to prove the superiority of ACE nail to other nails.

Proximal femoral nail (PFN):

PFN ("proximal femur nailing", Synthes Inc., Bettlach, Switzerland) one of the effective and preferred methods used to treat unstable trochanteric femur fractures and subtrochanteric fractures of the proximal femur was introduced by AO / ASIF in1996. As surgeons mastered the technique of PFN fixation and found it to have a superior effect in treating IT fractures, PFN became popular and more studies with favourable results were published.

PFN versus Gamma nail:

Herera A et al. in their comparative study of 250 pertrochanteric fractures which were treated with the simple GN or the PFN system (125 fractures in each group) reported a statistically significant difference in the incidence of neck screw cutout (4%) and fracture below the nail (3.2%) in the GN group. Similarly there was higher incidence of greater trochanter fracture upon insertion (15.2%) and reoperation (9 out of 125) in GN group.They also reported a higher incidence of secondary varus (7.2%) and collapse at the fracture site due to screw migration (8%) in PFN group. Cutout was significantly lower (0.8%) and also no case of diaphysial fracture was noted in PFN group [18]. Although Schipper et al. compared 211 PFN cases with 213 GN cases for unstable trochanteric fractures and concluded in a study in 2004 that more cases (7.6%) with “lateral protrusion" of the hip screws and a higher rate of revision procedure 18.4%, occurred in cases treated with PFN, the study also pointed out that this complication was as a result of poor positioning of the proximal screw(s) in the femoral head, rather than being implant related [19].

Out of 40 subjects of Papasimos et al. treated using PFN, 4 reported “Z” effect and 1 case of reverse “Z” effect due to which three cases had their implant removed [20]. Werner et al who introduced the term Z effect detected 5 cases with this complication among the 70 that underwent PFN fixation (7.1%) [21]. However, Morihara et al. in a their study showed PFN to have fewer complications as there were no cases of cut-out, Z-effect or periprosthetic fracture in 87 patients treated with PFN [22].

Although PFN has the added advantage of an antirotational hip pin inserted into the femoral neck via the proximal part of the nail which prevents rotation of head-neck, PFN surgery is not devoid of complications. The commonest of these is implant failure as a result of migration of screws, cut through of implant through the bone, breakage of implant, “Z” effect or reverse “Z” effect.

Controversial results have been mentioned in literature and encountered in practice in both

biomechanical and clinical comparisons between the conventional single screw design and the double screw system of the PFN. Schipper et al. in their biomechanical study reported that a design modification could lead to fewer cut-outs [23]. Hence, the single helical neck blade system is a well-received modified innovation of PFN.

Proximal Femoral Nail Antirotation (PFNA):

PFNA, a new generation nail, is a modification of the PFN and is the preferred implant more recently owing to its helical neck blade fixation that provides high stability, prevents antirotation, and antivarus collapse besides the surgery in itself involving minimal x-ray exposure, reduced perioperative blood loss, and biological fixation of the fractures with a single implant. PFNA II, Proximal Femoral Nail Antirotation-Asia for Asian patients were later developed by AO/ASIF as there were many intra- and postoperative complications, such as difficulty in nail insertion, pain in the hip and thigh, femoral shaft fracture, lateral blade migration, and lateral cortex splitting intraoperatively, reported due to the proximal diameter (17mm) being too large for Asian patients [24].

PFNA versus PFN and Gamma3:

In a comparison between PFNA and PFN, Jung Ho Park et al reported that PFNA produced better statistically significant results in terms of social function scores, mobility scores, and complication rates. No definite complication was seen in PFNA group except for 5 cases (27.7%) that reported mild persistent hip pain [25]. When comparing PFNA with Gamma3, J. Vaquero et al noted no significant difference in the overall clinical outcome and risk of complication during the first postoperative year. PFNA and Gamma3 had complication rate of 45% and 40% respectively. Although there were no significant difference in term of range of motion, clinical scores and radiological outcomes, 3 cases treated with PFNA reported of cut-out due to improper position of the blade/screw and the incorrect tip-to-apex rather than due to implant [26]. However, the superiority of PFNA over Gamma3 with respect to lesser blood loss and shorter fluoroscopy time was reported by Xu Yaozeng et al in their research on 55 PFNA and 52 Gamma3 cases. But no significant differences in functional outcome or intra-operative and postoperative complications were established in this study [27].

Shin Young-Soo et al found that cut-out was associated with lag screw or blade position in the femoral head measured by Tip-apex distance (TAD) and not with reduction quality. An avascular necrosis of the femoral head of2.8 %, cut out of 1.7% and reoperation rate of 3.3% was observed in PFNA II group [28]. Similarly, Zhang Sheng et al reported 2 cases of intraoperative femoral shaft fractures, 2 cut outs and 4 lateral blade migration out of 56 cases treated with PFNA II [29]. PFNA II developed for Asian patients also resulted in complications like intraoperative femoral shaft fracture, cut-out and lateral blade migration but authors have reported that these complication were due to improper position of the blade/screw and the incorrect tip-to-apex distance rather than the design of the implant.

PFNA is a very popular device in recent clinical practise and many studies have been performed comparing its biomechanical properties, outcomes and complications. Studies have shown this device to be favourable in the treatment of unstable IT fractures since the associated complications were relatively fewer and the functional outcomes were superior in PFNA compared to other nails.

Reconstruction Interlocking Nail:

Reconstruction interlocking nail which is also known as cephalomedullary nail is an antegrade, intramedullary femoral nail that provides fixation into femur head and neck and are used in complex, proximal femur fractures such as fracture neck of femur, IT fracture, subtrochanteric fracture and in ipsilateral fracture neck or IT fracture with fracture shaft of femur. Reconstruction nails consist of two proximal interlocking screws that permit sliding lag-screw fixation into the femoral head, therefore enhancing rotational stability in the proximal part while the distal interlocking screws provide rotational and axial stability. Russell Taylor Reconstruction Nail is the original reconstruction nail (Smith & Nephew, Memphis, TN) also known as "second-generation interlocking nail" was introduced in 1986. It is a closed-section implant designed for a piriformis entry and has a 15 mm proximal cross section with 135-degree angle-reconstruction screws.

Russel Taylor Nail versus Gamma nail:

Starr AJ et al. in their randomized study compared 17 patients in each Russell Taylor Nail and Long Gamma Nail group, found no significant difference in incision length, duration of surgery, blood loss, reduction, union rate complication and outcome between these devices [30]. Reconstruction interlocking nails are more preferred for the treatment of subtrochanteric fractures, fracture shaft of femur and ipsilateral femoral neck/shaft fracture. However, comparative studies specific to IT fracture are few.

Third-generation reconstruction nail:

The proximal cross section of third generation reconstruction nail (Recon Nail, TriGen TAN) is 13 mm and is angled at 5°and has 12° anteversion. Screw placement for the reconstruction mode is at the standard 130^0 or 135^0.

Third generation reconstruction nail versus Gamma nail:

When comparing gamma nail and reconstruction nail for treatment of IT fracture in the elderly one study reported that the average duration of hospitalization after operation and intraoperative blood loss in the Gama nail fixation group to be lesser than that of reconstruction nail fixation group. As for the number of cases that achieved good to excellent functional evaluation, there was no statical difference between either

groups. Both Gamma nail and reconstruction nail fixations were fit for IT fractures in elderly patients. Gamma nail fixation has the advantages of lesser operative time and blood loss and a shorter hospital stay [31].

Third generation reconstruction nail versus PFNA:

PFNA was compared to the reconstruction trochanteric antigrade nail (TAN) in the management of reverse oblique IT fracture, published in Injury, Int. J. Care Injured in 2015. The study suggested that the use of reconstruction system with two screws such as TAN may be suitable for reverse oblique IT fractures and concluded that in their experience, PFNA is perhaps less effective than TAN in treating reverse obliquity IT fractures as it allows excessive movement at the fracture site and can lead to delay union or failure [32]. Similarly, a comparative study of PFNA versus Reconstruction Nail in treatment of comminuted proximal femoral fracture that compared 10 cases treated with Recon Nail and 13 cases treated with PFNA noted that PFNA provides a shorter operation time, less blood loss, better realignment ability and reduces the incidence of reoperation. However for comminuted proximal femoral fractures, the use of either PFNA or Recon nail is clinically effective [33].

Although studies have reported both PFNA and Reconstruction nails to have good clinical outcomes, only few trials have compared the outcomes. PFNA has the advantages of reliable fixation， short fracture healing time and superior hip function when compared to Reconstruction Interlocking nail [34]. Similarly, another article has considered the PFNA a better device than Reconstruction Interlocking nail as it provided a shorter operation time, lesser blood loss, better realignment ability and reduced the incidence of reoperation in the treatment of comminuted proximal femoral fracture [35].

Fourth-generation reconstruction nail: InterTan:

The InterTan Nail system is a fourth- generation reconstruction interlocking nail introduced in 2005 and has a trapezoidal proximal end with two cephalocervical screws of which larger superior is 11 mm lag screw and smaller inferior 7 mm compression screw. There have been many studies comparing InterTan with other new generation nails and InterTan has been found to be more suitable for ITfracture with lesser complications.

InterTan versus Gamma3:

Wu et al. in their study found that the incidences of cut-out and periprosthetic femoral shaft fracture were significantly higher in Gamma3 group than in InterTan group. This study included 87 patients in InterTan and 174 in G3 group. And found 1cut-out and 1 femoral shaft fracture in InterTan group which was significantly lower to 14 cut-out and 10 femoral shaft fractures in Gamma3 group. The study concluded that InterTan gives a better outcome in unstable trochanteric fracture when compared to Gamma3 [36]. Groch J.B

et al in their study comparing 51 cases treated with Gamma3 nail and 53 cases with InterTan nail, reported 2 InterTan cases with superior implant protrusion caused by poor implant placement associated with learning curve in InterTan group. However regarding functional outcome and hospital stay, the InterTan group showed better follow up results at 6 months [37].

InterTan versus PFNA:

Yanfeng Huang et al in their biomechanical comparative study between InterTan and PFNA reported that InterTan has firmer and biomechanically superior performance [38]. Zhang Sheng et al reported two cases of femoral shaft fracture during intraoperative period, two cases of cut outs and four lateral blade migration among 56 cases treated with PFNA II. Patients treated with PFNA II had a shorter operation time, shorter fluoroscopy time, and lesser intraoperative blood loss than InterTan group. There was no significant statistical difference in general complications, local complications, walking ability, Harris Hip Scores, or hip range of motion in the final follow-up [39]. No cut out, no revision surgery and implant removal was required in any cases of InterTan or PFNA in a study by Seyhan Mustafa et al. The rates of displacement of the proximal screw in reversre direction, decreased varus angle and shortening of the proximal femur were significantly higher in the PFNA group [40]. Similarly, in a study by Ruecker A H et al. no loss of reduction, no uncontrolled neck collapse, no non-unions, no varus malunions, no periprosthetic femoral shaft fractures, and no implant failures occurred among the 100 displaced IT fractures treated with InterTAN implant. Two cases developed superior implant protrusion caused by poor initial implant placement [41].

DISCUSSION

Studies have shown that Gamma3, PFNA and InterTan are better devices among the intramedullary nails. Many comparative studies showed better results for InterTan when compared to other third generation intramedullary nails- PFNA and Gamma3. A review of these articles can lead us to a conclusion that InterTan with better functional outcomes and significantly lesser complications like cut-out and periprosthetic femoral shaft fracture is superior to Gamma3 [36, 37]. Some complication seen in the studies were due to the learning curve and as reported by some authors the cut-out were mostly due to the tip axis distance rather than the implant itself.

The intramedullary fixation system has a greater biomechanical advantage than the extramedullary fixation system [38], and both InterTan and PFNA can effectively resist the rotation of the femoral head and neck. Therefore, patients can be encouraged for early weight-bearing activities which will shorten the patient's non ambulatory period, promote blood circulation of limbs, provide good conditions for the healing of the fracture, lower chances of deep vein thrombosis, joint stiffness and other probable complications. However, most studies showed that complication rate were lower in InterTan nail than that of PFNA [40, 41]. Both InterTan nail and PFNA require minimally invasive surgical procedures, and InterTan nail has two

proximal screws while PFNA has only one screw and this could be the reason for longer duration of operation in cases treated with InterTan nail than those treated with PFNA. Besides, severity of fracture and the surgeon's level of proficiency with the instruments in the surgery may be the reasons for longer duration of operation.

The proximal valgus angle of InterTan nail is 4^0 so a 3 cm skin incision can be given 2-3cm proximal to the tip of the greater trochanter, 3 cm skin incision can be given to meet the insertion of protective sleeve into the guide wire entry point. PFNA nail has 6^0 proximal valgus angle, 5 cm skin incision can meet the protection sleeve insertion into the guide pin entry point. The diameter of the InterTan protective sleeve is 16 mm, while that of PFNA is 20 mm, and the cross sectional area of the sleeve is 113 mm^2. The InterTAN standard reamer has a diameter of 12.5 mm and reamer for PFNA has 17mm diameter hence the destruction of the cortex and medullary cavity is greater in PFNA when the medullary cavity is reamed. The proximal diameter of InterTan nail is about 15 mm and the shortest length is 180 mm. While the proximal diameter of PFNA nail is 16mm and shortest length is 170 mm. When calculate the volume, InterTan volume is lower than the PFNA by 434.04 mm^3. Therefore, theoretically, the amount of intraoperative bleeding when using InterTan nail should be lesser than PFNA, but the studies showed no significant difference in amount of blood loss between these group [41]. Other factors that could be associated with the amount of blood lost during surgery are severity of fracture, duration of surgery, coagulation profile, etc. which could have affected the amount of bleeding during surgery.

InterTan nail with the trapezoid design and two integrated screws function as worm gear mechanism to overcome "Z" effect which is a very common complication in traditional intramedullary system (inclucing PFNA), and provides linear compression, rotational stability, prevent fixation failure and so on. The distal tip of the InterTan nail has a 22 mm long split "clothes pin" which can effectively reduce the overall cross sectional stiffness, reduce the potential for periprosthetic fracture distal to the nail and post-operative thigh pain [42]. These advantages eventually provide InterTan nail with less complication and higher Harris hip score than PFNA and can be considered the most preferable and superior device in treating IT fractures.

CONCLUSION

Intramedullary devices that were introduced in the 80s and 90s had more complications when compared to extramedullary devices. But they were still preferred as they were minimally invasive, reduced blood loss due to the percutaneous technique resulted in minimal tissue damage and shorter operation time. The main complications seen with these devices were femoral shaft fracture, cut-out, and instability. As these devices were later modified and newer devices were introduced the rate of incidence of the complications were reported lesser. Complications such as cut-out rates and Z effect with Gamma nail, Proximal femoral nail and Dynamic hip screw have been reported ranging from 3% to 10% but these are lower with the PFNA (1%-

3%)and is not existent in InterTan nail. Similarly the incidence of periprosthetic femoral shaft fracture is significantly lower in InterTan when compared to PFNA, Gamma3 and other intramedullary devices. Many studies comparing InterTan with Gamma3, PFNA and DHS showed better performance and concluded that InterTan is more reliable and beneficial in treatment of unstable IT fracture. Similarly biomechanical studies also concluded that InterTan is more rigid, stiff and stable when compared to PFNA and Gamma3.Hence, this device can be considered the most preferable and superior in the treatment of IT fractures. However, since the number of studies comparing InterTan with other devices is limited, further research may be required to study more potential advantages to establish its superiority.

REFERENCES

1. Ray Marks. Hip fracture epidemiological trends, outcomes, and risk factors, 1970–2009.Int J Gen Med. 2010; 3: 1–17.2010 Apr 8; 3:1-17.
2. Roche JJ 1, Wenn RT, Sahota O, Moran CG. Effect of comorbidities and postoperative complications on mortality after hip fracture in elderly people: prospective observational cohort study.BMJ. 2005 Dec 10; 331(7529):1374.
3. Tan ST, Tan WP, Jaipaul J, Chan SP, Sathappan SS. Clinical outcomes and hospital length of stay in 2,756 elderly patients with hip fractures: a comparison of surgical and non-surgical management. Singapore Med J. 2017 May; 58(5):253-257. doi: 10.11622/smedj.2016045.
4. Yoon BH, Baek JH, Kim MK, Lee YK, Ha YC, Koo KH. Poor prognosis in elderly patients who refused surgery because of economic burden and medical problem after hip fracture.J Korean Med Sci. 2013 Sep; 28(9):1378-81. doi: 10.3346/jkms.2013.28.9.1378.
5. Curtis MJ 1, Jinnah RH, Wilson V, Cunningham BW. Proximal femoral fractures: a biomechanical study to compare intramedullary and extramedullary fixation.Injury. 1994 Mar; 25(2):99-104.
6. Cyril Jonnes, MS, Shishir SM, MS, and Syed Najimudeen, MSType II Intertrochanteric Fractures: Proximal Femoral Nailing (PFN) Versus Dynamic Hip Screw (DHS). Arch Bone Jt Surg. 2016 Jan; 4(1): 23–28.
7. O'Brien PJ 1, Meek RN, Blachut PA, Broekhuyse HM, Sabharwal S. Fixation of intertrochanteric hip fractures: gamma nail versus dynamic hip screw. A randomized, prospective study. Can J Surg. 1995 Dec; 38(6):516-20.
8. Habernek H, Wallner T, Aschauer E, Schmid L. Comparison of ender nails, dynamic hip screws, and Gamma nails in the treatment of peritrochanteric femoral fractures. Orthopedics. 2000 Feb; 23(2):121-7.
9. Saarenpää I, Heikkinen T, Jalovaara P. Treatment of subtrochanteric fractures. A comparison of the Gamma nail and the dynamic hip screw: short-term outcome in 58 patients. Int Orthop. 2007 Feb; 31(1):65-70.
10. Bojan AJ, Beimel C, Speitling A, Taglang G, Ekholm C, Jönsson A. 3066 consecutive Gamma Nails. 12 years experience at a single centre. BMC Musculoskelet Disord. 2010 Jun 26; 11:133. doi: 10.1186/1471-2474-11-133.

11. Schupfner R, Käsmann LT, Wagner W, Schulz AP. Complications in Treatment of 31-A Fractures with Trochanteric Gamma Nail (TGN) Versus Gamma3 Nail (G3N) - A Review of 217 Cases. Open Orthop J. 2016 Aug 10; 10:389-395. doi: 10.2174/1874325001610010389.
12. Georgiannos D, Lampridis V, Bisbinas I. Complications following Treatment of Trochanteric Fractures with the Gamma3 Nail: Is the Latest Version of Gamma Nail Superior to Its Predecessor? Surg Res Pract. 2014; 2014:143598. doi:10.1155/2014/143598.
13. Pascarella R, Fantasia R, Maresca A, Bettuzzi C, Amendola L, Violini S, Cuoghi F, Sangiovanni P. How evolution of the nailing system improves results and reduces orthopedic complications: more than 2000 cases of trochanteric fractures treated with the Gamma Nail System. Musculoskelet Surg. 2016 Apr; 100(1):1-8. doi: 10.1007/s12306-015-0391-y.
14. Buecking B,Bliemel C,Struewer J,Eschbach D,Ruchholtz S,Müller T. Use of the Gamma3™ nail in a teaching hospital for trochanteric fractures: mechanical complications, functional outcomes, and quality of life. BMC Res Notes, 2012, 5,651.
15. Winnock de Grave P, Tampere T, Byn P, Van Overschelde J, Pattyn C, Verdonk R. Intramedullary fixation of intertrochanteric hip fractures: a comparison of two implant designs. A prospective randomised clinical trial. Acta Orthop Belg. 2012 Apr; 78(2):192-8.
16. Efstathopoulos NE, Nikolaou VS, Lazarettos JT. Intramedullary fixation of intertrochanteric hip fractures: a comparison of two implant designs. Int Orthop. 2007 Feb; 31(1):71-6.
17. Vidyadhara S,Rao SK. One and two femoral neck screws with intramedullary nails for unstable trochanteric fractures of femur in the elderly--randomised clinical trial. Injury, 2007, Jul, 38, 7,806-14.
18. Herrera A, Domingo LJ, Calvo A, Martinez A. A comparative study of trochanteric fractures treated with the Gamma nail or the proximal femoral nail. Int Orthop. 2002; 26(6):365-9.
19. Schipper IB 1, Steyerberg EW, Castelein RM, van der Heijden FH, den Hoed PT, Kerver AJ, van Vugt AB. Treatment of unstable trochanteric fractures. Randomised comparison of the gamma nail and the proximal femoral nail. J Bone Joint Surg Br. 2004 Jan; 86(1):86-94.
20. Papasimos S 1, Koutsojannis CM, Panagopoulos A, Megas P, Lambiris E . A randomised comparison of AMBI, TGN and PFN for treatment of unstable trochanteric fractures. Arch Orthop Trauma Surg. 2005 Sep; 125(7):462-8.
21. Werner-Tutschku W , Lajtai G, Schmiedhuber G, Lang T, Pirkl C, Orthner E. Intra- and perioperative complications in the stabilization of per- and subtrochanteric femoral fractures by means of PFN.Unfallchirurg. 2002 Oct; 105(10):881-5.
22. Morihara T Arai Y, Tokugawa S, Fujita S. Proximal femoral nail for treatment of trochanteric femoral fractures. Journal of Orthopaedic Surgery. 2007; 15(3):273-7.
23. Schipper IB , Bresina S, Wahl D, Linke B, Van Vugt AB, Schneider E. Biomechanical evaluation of the proximal femoral nail. Clin Orthop Relat Res. 2002 Dec ;(405):277-86.

24. Yaozeng X 1, Dechun G, Huilin Y, Guangming Z, Xianbin W. Comparative study of trochanteric fracture treated with the proximal femoral nail anti-rotation and the third generation of gamma nail. Injury. 2010 Dec; 41(12):1234-8.
25. Park JH, Lee YS, Park JW, Wang JH, Kim JG. A comparative study of screw and helical proximal femoral nails for the treatment of intertrochanteric fractures. Orthopedics. 2010 Feb; 33(2):81-5. doi: 10.3928/01477447-20100104-11.
26. 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, Dec; 43 Suppl 2, S47-54.doi: 10.1016/S0020-1383(13)70179-7.
27. Xu Y,Geng D,Yang H,Wang X,Zhu G. Treatment of unstable proximal femoral fractures: comparison of the proximal femoral nail antirotation and gamma nail 3. Orthopedics, 2010, Jul, 33, 7,473.
28. Shin YS 1, Chae JE 1, Kang TW 2, Han SB 3. Prospective randomized study comparing two cephalomedullary nails for elderly intertrochanteric fractures: Zimmer natural nail versus proximal femoral nail antirotation II. Injury. 2017 Jul; 48(7):1550-1557. doi: 10.1016.
29. Zhang S 1, Zhang K, Jia Y, Yu B, Feng W. InterTan nail versus Proximal Femoral Nail Antirotation-Asia in the treatment of unstable trochanteric fractures. Orthopedics. 2013 Mar; 36(3):e288-94. doi: 10.3928/01477447-20130222-16.
30. Starr AJ,Hay MT,Reinert CM,Borer DS,Christensen KC. Cephalomedullary nails in the treatment of high-energy proximal femur fractures in young patients: a prospective, randomized comparison of trochanteric versus piriformis fossa entry portal. J Orthop Trauma, 2006, Apr, 20, 4,240-6. PMID: 16721238.
31. Huang Han wei, JIANG, Hai ying, WU Jun guo, QIAN Guang, LI Fang ming. Comparison of Gamma Nails and Reconstruction Nails in Intramedullary Fixation for Intertrochanteric Hip Fractures in the Aged. Chinese Journal of Clinical Medicine. 2009. Vol. 16, No. 3.
32. Makki D 1, Matar HE 2, Jacob N 3, Lipscombe S 4, Gudena R 5. Comparison of the reconstruction trochanteric antigrade nail (TAN) with the proximal femoral nail antirotation (PFNA) in the management of reverse oblique intertrochanteric hip fractures. Injury. 2015 Dec; 46(12):2389-93. doi: 10.1016/j.injury.2015.09.038. Epub 2015 Oct 13
33. Fu-Ting Huang, MD; Kai-Cheng Lin, MD; Shan-Wei Yang, MD; Jenn-Huei Renn, MD; Comparative Study of the Proximal Femoral Nail Antirotation Versus the Reconstruction Nail in the Treatment of Comminuted Proximal Femoral Fracture. Orthopedics. 2012 Jan 16; 35(1):e41-7. doi: 10.3928/01477447-20111122-02.
34. Wang Xiao-feng, Huang Yu-liang, Wu Hong-bo, Wu Zhe-hui, Liu Zhi-bin. Comparison of effect of the long type proximal femoral nail antirotation and reconstruction interlocking nail in treating femoral shaft fracture combined with ipsilateral intertrochanteric fracture. J Trauma Surg, 2016, Vol. 18, No.10.
35. Huang FT 1, Lin KC, Yang SW, Renn JH. Comparative study of the proximal femoral nail antirotation

versus the reconstruction nail in the treatment of comminuted proximal femoral fracture. Orthopedics. 2012 Jan 16; 35(1):e41-7. doi: 10.3928/01477447-20111122-02.

36. Wu D, Ren G, Peng C, Zheng X, Mao F, Zhang Y. InterTan nail versus Gamma3 nail for intramedullary nailing of unstable trochanteric fractures. Diagn Pathol. 2014 Oct 1; 9:191. doi: 10.1186/s13000-014-0191.
37. Berger-Groch J 1, Rupprecht M, Schoepper S, Schroeder M, Rueger JM, Hoffmann M. Five-Year Outcome Analysis of Intertrochanteric Femur Fractures: A Prospective Randomized Trial Comparing a 2-Screw and a Single-Screw Cephalomedullary Nail. J Orthop Trauma. 2016 Sep; 30(9):483-8. doi: 10.1097/BOT.0000000000000616.
38. Huang Y, Zhang C, Luo Y. A comparative biomechanical study of proximal femoral nail (InterTAN) and proximal femoral nail antirotation for intertrochanteric fractures. Int Orthop. 2013 Dec; 37(12):2465-73. doi: 10.1007/s00264-013-2120-1.
39. Seyhan M, Turkmen I, Unay K, Ozkut AT. Do PFNA devices and Intertan nails both have the same effects in the treatment of trochanteric fractures? A prospective clinical study. J Orthop Sci. 2015 Nov; 20(6):1053-61. doi: 10.1007/s00776-015-0750-4.
40. Ruecker AH 1, Rupprecht 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; J Orthop Trauma. 2009 Jan; 23(1):22-30. doi: 10.1097/BOT.0b013e31819211b2.
41. Hui Zhang , Xiaoxiao Zhu , Genwang Pei , Xianshang Zeng , Nan Zhang , Ping Xu , Deng Chen, Weiguang Yu and Xinchao Zhang. A retrospective analysis of the InterTan nail and proximal femoral nail anti-rotation in the treatment of intertrochanteric fractures in elderly patients with osteoporosis: a minimum follow-up of 3 years. Journal of Orthopaedic Surgery and Research (2017) 12:147 DOI 10.1186/s13018-017-0648-2.
42. Weiguang Yu, Xinchao Zhang, Xingfei Zhu, Jun Hu, and Yunjiang Liu. 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. J Orthop Surg Res. 2016; 11: 10. doi: 10.1186/s13018-016-0344-7.