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Original Article

Comparision of PFN and INTERTAN nail for unstable intertrochanteric femoral fracture in mobile patients

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Abstract: Objectives: The ideal implant for the treatment of an unstable intertrochanteric femoral fracture is still a matter of discussion. Intramedullary nails with different varieties of design offer good options in treatment. The aim of this study was to compare two intramedullary nails in different design and reveal the differences by evaluating radiological parameters of patients with unstable intertrochanteric femoral fracture in mobile patients. Material and Method: PFN and INTERTAN nails in two groups were compared overall in 63 patients. Reduction quality and the differences on varus collapse and neck shortening of femur by measuring radiological parameters on early and late postoperative X-rays were examined. Results: Similar radiological results were found between PFN and INTERTAN nails. Reduction quality of fractures was similar between groups. There was a significant difference only in the varus collapse degrees between groups ($p<0,001$) but no difference in neck shortening. The results revealed that INTERTAN has better resistance to occur varus collapse and the same prevention for neck shortening. Conclusion: Implant design is the one of major factors that may affect the results. INTERTAN nail made a difference in varus collapse of the neck but not in neck shortening. The results of this study have shown that the nail with two adjacent lag screws provides slightly better fixation properties preventing varus collapse than the nail with two separate lag screws. INTERTAN and PFN are currently good options in the treatment of unstable intertrochanteric femoral fractures and sustain enough stability during healing period in mobile patients.

Keywords: INTERTAN, PFN, intertrochanteric femur fracture, varus collapse

Introduction

Treatment of unstable intertrochanteric femoral fractures is challenging due to difficulties in achieving anatomic reduction and stable fixation [1-3]. Treatment of these fractures evolved continuously during the last decades beginning from blade plates to dynamic hip screws and then to intramedullary devices. There are numerous implants on the market, all with the suggestion of more stable fixation in treatment of unstable intertrochanteric intertrochanteric femoral fractures. The ideal treatment of an unstable intertrochanteric femoral fracture is still a matter of discussion. Operative treatment must achieve immediate full-weight-bearing mobilization in early postoperative period [4, 5]. Biomechanical studies have shown that intramedullary devices were more rigid than extramedullary devices [6-8]. Intramedullary devices gained popularity especially in unstable intertrochanteric femoral fractures because of its biomechanical advantages [9-13].

Varus collapse and neck shortening are some of encountered complications during the healing period of intramedullary device [1, 14-16]. When technical errors are excluded, the major factor that is held responsible for these complications is the mechanical properties of implant [17-19]. Trigen INTERTAN (Intertrochanteric Antregrade Nailing, Smith & Nephew, Inc. Memphis, USA) and PFN (Proximal Femoral Nail, Synthes, Switzerland) are two intramedullary fixation device which are used for fixation of unstable intertrochanteric fractures but has different design rationales and characteristics. Both nails are still being used in unstable intertrochanteric femoral fractures but we are not aware of any study comparing the PFN and INTERTAN nails *in vivo*.

This study aimed to reveal the differences on varus collapse and neck shortening of these two nails by evaluating radiological parameters of patients with unstable intertrochanteric femoral fracture in mobile patients. Displacements under the physiological loadings in two directions of head and neck relative to the nails reflected the condition about the stability of fixation. Radiological examination after postoperative period is most common and easy way to control the stability of fixation. There has been no study in the literature to compare to stability properties of PFN and INTERTAN nail by observing radiological parameters.

Material and methods

All patients who had intertrochanteric femoral fracture in our database were searched retrospectively between 2002-2012. A total of 119 patients were followed who had been operated for unstable intertrochanteric femoral fracture (between A2.2 and A3.3) according to Arbeitsgemeinschaft für Ostheosynthesefragen/Orthopaedic Trauma Association (AO/OTA) classification. The following were exclusion criteria: Patients were eliminated who had been operated using a device other than a PFN and INTERTAN nail. Patients with pathological fractures due to secondary osteoporosis (malignancy, steroid induced etc.) were excluded. İmmobilization of patients was another exclusion criteria. In the first postoperative month, the patients who were not able to mobilize due to mechanical or medical problems such as failure of fixation or secondary health problems (multi organ failure, dementia, death, etc.) were excluded from the study due to compare nails under physiological loading.

At the end 63 patients who had unstable intertrochanteric femoral fracture underwent PFN and INTERTAN nail fixation and had follow-up for a minimum 12 months were the subjects of the study. Choice of implant for treatment was random but surgeons were same.

Surgical technique was similar in both nails. The reduction was achieved by closed manipulation on traction table under anesthesia. It was verified using fluoroscopy. Approximately 5 cm length incision was made on proximal to the tip of trochanter. Soft tissue was protected with blunt dissection. The guide-wire was inserted into the medullary canal from the tip of trochanter and its position was controlled in both anterior and lateral plan. Proximal femur was reamed with reamer sized 16 mm. The guide wire was removed after the intramedullary nail inserted over the wire. After the confirmation of anteversion of the nail, two proximal locking screws in proper length were inserted.

INTERTAN nail has two integrated proximal screws, which are the lag screw in a diameter of 11 mm and the compression screw in a diameter of 7 mm (as a rule 5 mm shorter then lag screw length).

Two but separate screws were used for proximal fixation in PFN. The lag screw in a diameter of 11 mm was inserted inferior part of femoral neck and the hip pin in a diameter of 6.5 mm (as a rule 5 mm shorter than lag screw) was inserted superior part of femoral neck. Static distal locking was made in same manner for both nails.

Antibiotic and thromboembolism prophylaxis were administered routinely. The rehabilitation procedure was identical for all patients. Patients were allowed to mobilize and weight-bearing walking as tolerated on second postoperative day.

Measurements were made on the digital X-rays that were taken on postoperative early period at one month and late period at one year. Radiological parameters such as quality of reduction, varus collapse and neck shortening were measured on digital x-rays by two-experienced surgeon.

The quality of reduction according to “Baumgaertner criteria” [15] was measured. According to Baumgaertner criteria: For a reduction to be considered good, there had to be normal or slight valgus alignment on the anterior-posterior x-ray, less than 20 degrees of angulation on the lateral x-ray, and no more than four millimeters of displacement of any fragment. If only one criterion met, the reduction was considered as acceptable. A poor reduction met neither criteria [15].

Varus collapse was defined as any varus change in neck shaft angle between early and late postoperative x-rays. The neck shaft angle was measured angle between the line connecting the mid-point of femoral neck with center of

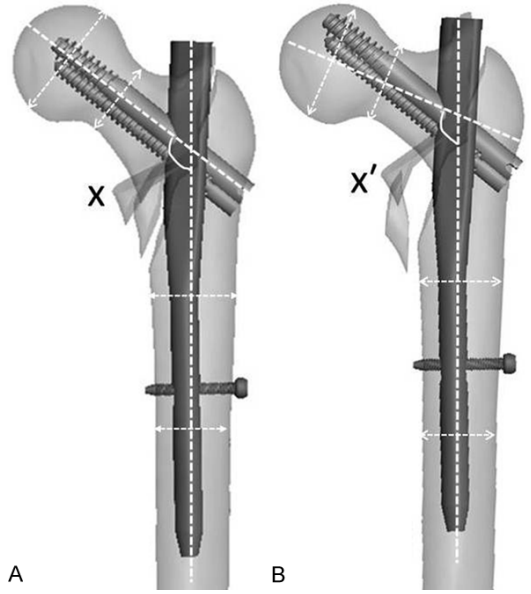

Figure 1. Varus collapse was illustrated on PFN. Varus collapse was calculated by subtracting x' value (varus degree in late period) (B) from x value (varus degree in early period) (A).

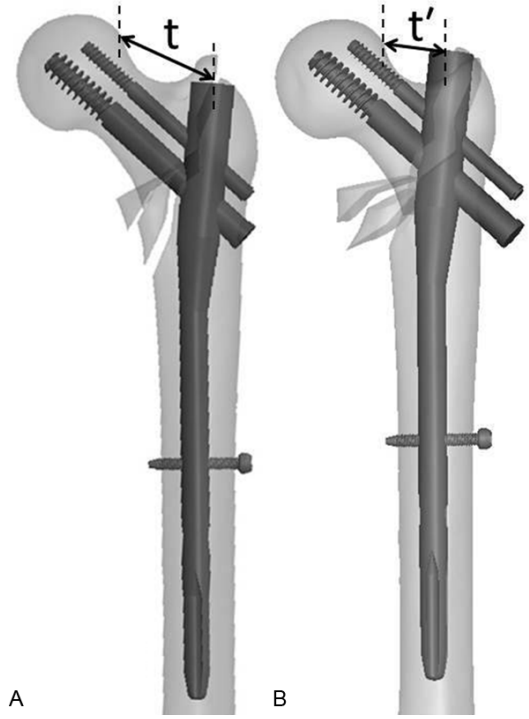

Figure 2. Neck shortening was illustrated on INTERTAN nail. Neck shortening was calculated by subtracting t' value (distance in late period) (B) from t value (distance in early period) (A).

head and mid-diaphyseal line of femur (**Figure 1**).

Neck shortening was measured by calculating the sliding amount of femoral head on screws inside nail between early and late postoperative x-rays. Neck shortening was detected by measuring the distance between superior edge of the femoral head with femoral neck and the tip of the nail (**Figure 2**).

There were different sizes in diameters for both nails in the market. 10, 11, 12 mm for PFN and 10, 11.5, 13 mm for INTERTAN are available. Diameters of nails that were used for fixation were recorded.

Statistical analyses were performed using the SPSS software package 16.0 (Aspire Software International, Ashburn, VA). Mann-Whitney U and student-t tests were used to compare the groups.

Results

A total of 34 patients were female, 29 patients were male of 63 patients that were included the study. The mean age of the patients at time of fracture was 73.85 (42-93). Patients were divided into two groups according to implant choice for treatment. There were 31 patients in PFN group and 32 patients in INTERTAN group. The distribution of ages of patients according to groups was similar (p=0.788). **Table 1** shows demographics and distribution of fracture types. All fractures were unstable and the distribution of AO/OTA fracture types was similar in both groups (p=0.639) (**Table 1**).

The evaluation of postoperative reduction in accordance with Baumgaertner criteria revealed that in PFN group; reduction was good in 23 patient (36.5%), acceptable in 8 patient (12.6%), bad in only 1 (1.5%) patient and in INTERTAN group; reduction was good in 28 patient (44.4%), acceptable in 4 patient (6.3%). The quality of reduction for fractures was same in both groups (mean: 2.63 for PFN and mean: 2.87 for INTERTAN) (p=0.182).

The average degree of the increase on varus of femoral neck was 5.07° in PFN group and 1.84° in INTERTAN group. There was a significant difference in the increase of varus degrees between the groups (p<0.001) (**Figure 3**).

Table 1. Demographics of groups and distribution of patients according to AO classification

	PFN	INTERTAN
Number of patients	31	32
Average age (years)	74.8 (59-93)	72.9 (42-89)
Number of male patients	15	14
Number of female patients	16	18
AO/OTA classification		
A2		
A2.2	17	21
A2.3	5	3
A3		
A3.1	5	2
A3.2	2	0
A3.3	2	6

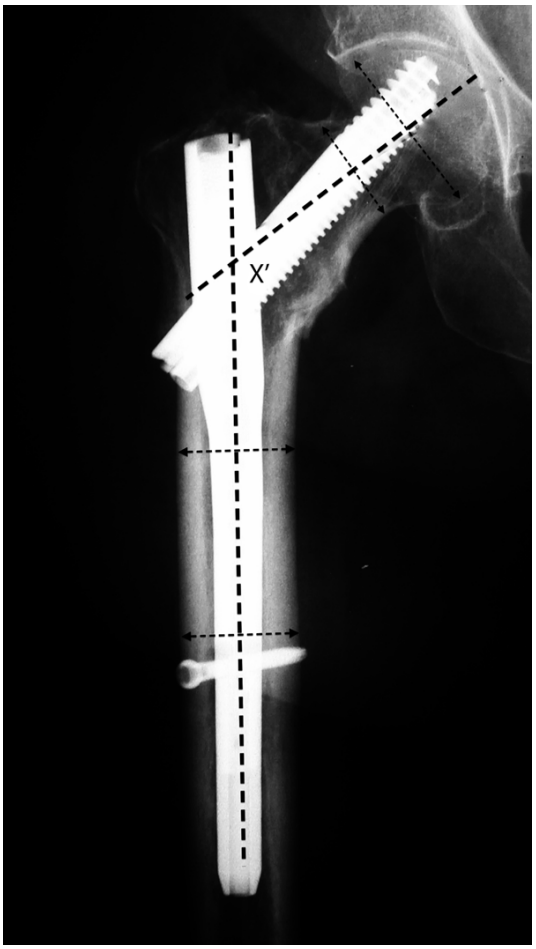

Figure 3. Varus collapse over the INTERTAN nail is seen in late postoperative roentgenogram. Neck shaft angle (x') between the dashed lines is measured.

When the neck shortening compared both groups, the mean neck shortening was measured 5.32 mm in PFN group and 5.15 mm in INTERATAN group. No significant difference was demonstrated between groups (p=0.787) (**Figure 4**).

The patients in both groups were at the same level according to their functional ability. All patients were mobile even the reduction in the operation room got worse at follow up.

The average diameter of nails was 10.52 mm (10-12) in PFN group and 10.65 mm (10-11.5) in INTERTAN group. The nail diameters were similar in both groups (p=0.239).

Discussion

Overall, radiological results for PFN and INTERTAN nails were compared. There has been no published study that compares radiological measurements for stability of PFN and INTERTAN nails used for the treatment of unstable intertrochanteric femoral fractures. A slight difference between radiological results in INTERTAN nail and PFN was found among the group of mobile patients who has been treated successfully without any complication.

All patients in this study had unstable intertrochanteric fracture with extremely thin lateral cortex and the types of fracture were similarly represented in both groups (**Table 1**). The similar groups of patients provided comparable subjects for the study.

Good reduction according to Baumgaertner criteria has been achieved in vast majority of our patients in both groups. There was no difference in reduction the two groups (p=0.182). It is well known that poor reduction results in poor prognosis in the fixation of hip fracture [1, 20]. The *in vivo* evaluation of implant based stability properties has some difficulties because of patient or surgeon based factors. This study aimed to minimize these factors by ruling out the failed cases and only included mobile patients in the study.

One of the radiological parameters was the varus collapse that is related with the fixation stability. The degree of varus collapse of PFN was remarkably higher than INTERTAN in our study. Varus collapse precedes cut-out of the screws from the femoral head [21]. Cut-out is a well-known failure phenomenon which needs a revision surgery [6]. The rate of varus collapse and then cut-out complication was reported 5%

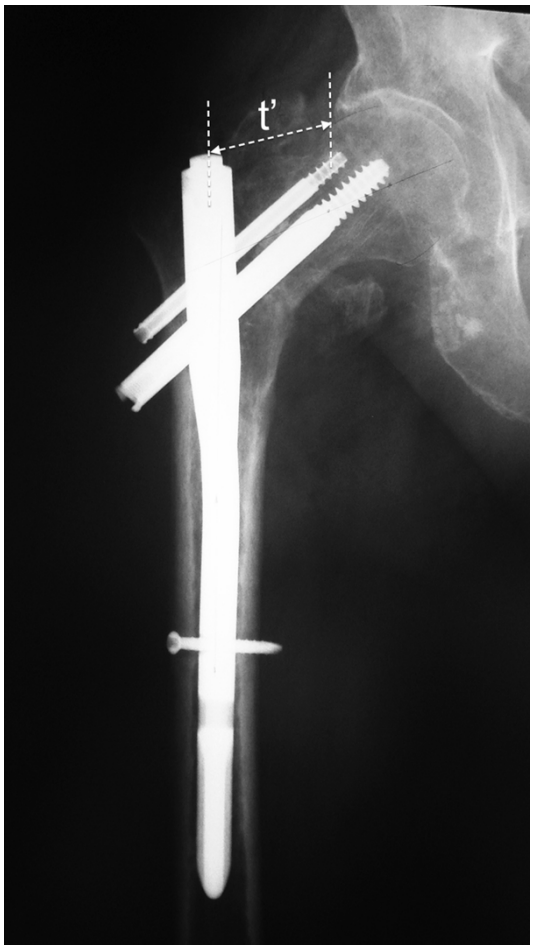

Figure 4. Neck shortening was calculated by measuring distance (t') in early and late postoperative X-rays. Distance (t') between PFN and superior edge of the femoral head is seen on late postoperative roentgenogram.

for INTERTAN nail by Ruecker et al. and 7% for PFN by Schipper et al. Generally improper screw placement into the head was blamed for this complication [19, 22]. The reduction quality instead of screw placement was evaluated. Proper screw placement needs good reduction and it provides good settlement of screws into head and it has preventive role for displacement. Technical errors minimized since both groups of patients had mostly good reduction.

There was no difference in the neck shortening amounts between nails. The sliding amounts in our study are compatible with literature [23]. INTERTAN nail and PFN allowed compression between fragments in fracture site. Fracture collapse on weight bearing in dynamic systems is important factor for healing of hip fractures fracture. Theoretically in finite element analysis, the lag screws with smaller diameter develop increased stresses in femoral head [24]. INTERTAN has different diameter and configuration of proximal screws than PFN. In this study, the sliding amount of neck was not affected by fixation of proximal screws.

The stems and distal locking screws of PFN and INTERTAN nails are available in similar sizes in the market. The diameters of nail stems had homogenous distribution between groups in our study. The major difference was the proximal screws. Flexion-extension movement in mobile patients results in loosening the bone and proximal screw interface. Theoretically a single large screw prevents loosening better than two separate thin screws [23]. In this study, INTERTAN has two proximal integrated interlocking screws acting as a one large screw beside PFN has two separate identical proximal screws. Both nails showed same resistance to loosening.

Both nails sustained sufficient stability during healing period in our study. The intramedullary hip nails offer several biomechanical and biological advantages in unstable intertrochanteric femoral fractures such as they provide rigid fixation and the indirect close reduction preserve local blood circulation and soft tissues envelope [17]. Intramedullary devices are advised as a first choice in fixation of unstable hip fractures [25].

There are some limitations of this study. Bone mineral density of our patients that may affect the interaction between bone and screw was not considered but our patients in two groups were similar in age distribution. This study also is limited to detect differences in physical capacity of the patients that may affect the stability between groups. The other weak point is our wide exclusion criteria for this study. Immobile patients were excluded to evaluate mechanical behaviors of nails in mobile patients, not to evaluate successful results. This means to ignore complications that may be related with implant such as knife effect, Z effect, and screw breakage. According to study plan, only mobile patients were analyzed and there was risk of bias due to exclusion.

In conclusion, there are still many questions regarding the components of ideal fixation devices. Implant design is the one of major fac-

tors that may affect the results. The results of this study have shown that both INTERTAN and PFN sustained adequate stability and two adjacent proximal lag screw prevented varus collapse better than two separate lag screws of unstable intertrochanteric fractures in mobile patients. Intramedullary nails are currently good options in the treatment of unstable intertrochanteric femoral fracture fractures and developments in implant design provide improving the outcomes.

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Disclosure of conflict of interest

None.

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