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# Comparative analysis of third-generation intramedullary nails: Retrospective evaluation of PFNA and intertan nails in unstable trochanteric fractures

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**Abstract**

**Aim:** The aim of this study is to retrospectively compare the outcomes of two different third-generation intramedullary nails, PFNA (Proximal Femoral Nail Antirotation) and Intertan, used in unstable trochanteric fractures in the geriatric population.

**Materials and Methods:** Our study included 85 patients aged 65 and older who underwent surgery for unstable intertrochanteric fractures at a single center between September 2021 and September 2023. Patients were divided into two groups based on the type of proximal femoral nail (PFN) used: the PFNA group and the Intertan group. These two groups were compared in terms of age, gender, operation duration, length of hospital stay, Harris hip scores, union rates, reoperation rates, and radiological parameters (reduction quality, Tip Apex Distance (TAD), Parker index (PI), collodiaphyseal angle (CDA)).

**Results:** There were no significant differences between the groups in terms of age, gender, length of hospital stay, Harris hip scores, reoperation rates, and radiological parameters (reduction quality, TAD, PI, CDA). However, the union rate was significantly higher in the Intertan group compared to the PFNA group ($p=0.008$). Additionally, the operation duration was significantly shorter in the PFNA group compared to the Intertan group ($p=0.03$).

**Conclusion:** In unstable trochanteric fractures, while PFNA nails may be more practical with appropriate reduction and implant positioning, Intertan nails provide a more rigid fixation and stabilization, resulting in higher union rates and lower risk of implant failure, making them implants that can be used safely.



## Introduction

In conjunction with the advancements in modern medicine and improvements in quality of life, the global elderly population is increasing, leading to a rise in the incidence of geriatric hip fractures [1, 2]. According to a study conducted by the International Osteoporosis Foundation, the annual incidence of hip fractures due to osteoporosis is currently estimated at 5.7 million globally, and it is expected to reach an annual 20 million by the year 2050 [3]. Despite trochanteric fractures due to osteoporosis occurring in elderly individuals following low-energy trauma such as simple falls, they also constitute significant reasons for mortality and morbidity. The goal of treatment is to perform surgery as soon as feasibly possible to enable early mobilization.

With the advancements in implant technology, a diverse range of implants has been utilized over time for the treatment of trochanteric femur fractures. In daily practice, dynamic hip screws (DHS) are more commonly utilized as extramedullary implants, while proximal femoral nails (PFN) are preferred as intramedullary implants. However, due to their applicability in both unstable and stable fractures and being a more minimally invasive approach, the use of PFNs has been increasing in recent years [4-6]. Depending on advancements in implant design technology, PFNs also exhibit different types within themselves. Following complications such as the 'z effect' observed with the application of second-generation nails, third-generation nails have been designed to provide a more rigid fracture fixation. Studies indicate that third-generation nails such as Proximal Femoral Nail Antirotation (PFNA) and Intertan nails can be safely used in unstable trochanteric fractures [7, 8]. However, the superiority of these two types of third-generation nails over each

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other is debatable, and a consensus has not been reached on this matter [9, 10]. The aim of this study is to compare the clinical and radiological outcomes of PFNA and Intertan nails in the treatment of unstable trochanteric femur fractures.

## Materials and Methods

*Study design*

The study was initiated after approval by the ethics committee with decision number 2023/4683 of Necmettin Erbakan University and conducted in accordance with the principles outlined in the Helsinki Declaration. Patients who presented to the emergency department of a single center between September 2021 and September 2023 and were diagnosed with intertrochanteric fractures were examined. Demographic information of these patients who met the inclusion criteria (age, gender, follow-up duration) was recorded. These patients were divided into two groups: those who underwent PFNA application and those who underwent Intertan application. The patients' operative times, hospital stays, Harris hip scores at postoperative 6 months, radiographic parameters (reduction quality, Parker index (PI), collodiaphyseal angle (CDA), and tip-apex distance (TAD)), and reoperation rates were evaluated.

*Inclusion and Exclusion criteria*

Inclusion criteria comprised patients aged 65 and older diagnosed with unstable fractures (31A2 and A3) according to the Arbeitsgemeinschaft für Osteosynthesefragen/Orthopedic Trauma Association (AO/OTA) classification following low-energy trauma (simple fall), with closed fractures and treated with proximal femur nail application. Exclusion criteria encompassed patients under 65 years old, those with high-energy traumas, fractures classified as stable per AO/OTA classification, patients with pathological fractures, individuals with ipsilateral or contralateral fractures in the lower or upper extremities, those unable to mobilize without support before the occurrence of an intertrochanteric fracture, cases of open fractures, and patients treated with open reduction and internal fixation.

*Radiographic measurements*

All measurements were made on X-rays. The cut-out was defined as the lag screw approaching within 1 mm or more of the femoral head margin from its placement after reduction [11]. The PI was determined by dividing the femoral head into three separate quadrants on anteroposterior (AP) and lateral X-ray images, as shown in Figure 1 (for the AP view: superior, central, inferior; and for the lateral view: anterior, central, posterior), based on the position of the lag screw. It was considered acceptable for the lag screw to be inferior or central on the AP view and centralized on the lateral view for the PI on radiographs [11, 12].

TAD was established by identifying the apex of the femoral head, defined as the point where a line drawn from the center parallel to the femoral neck connects with the subchondral bone. Radiographic magnification was determined by comparing the actual width of the implant with its measured width on the radiograph. Subsequently, the distance to the highest point in both the AP and lateral planes was multiplied by the radiographic magnification to obtain the actual values (Figure 2). The TAD was then calculated by summing up these values.

The quality of reduction was assessed according to the criteria proposed by Baumgaertner et al. [13]. In accordance with this, normal or mildly valgus alignment on the AP

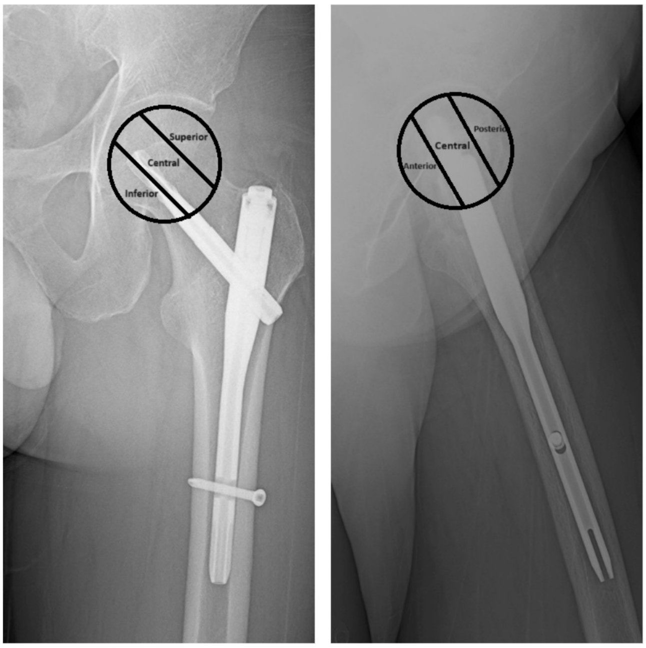


**Figure 1.** For the lag screw, being positioned inferiorly or centrally on AP views, and centered on the lateral view, is considered acceptable according to the Parker index.

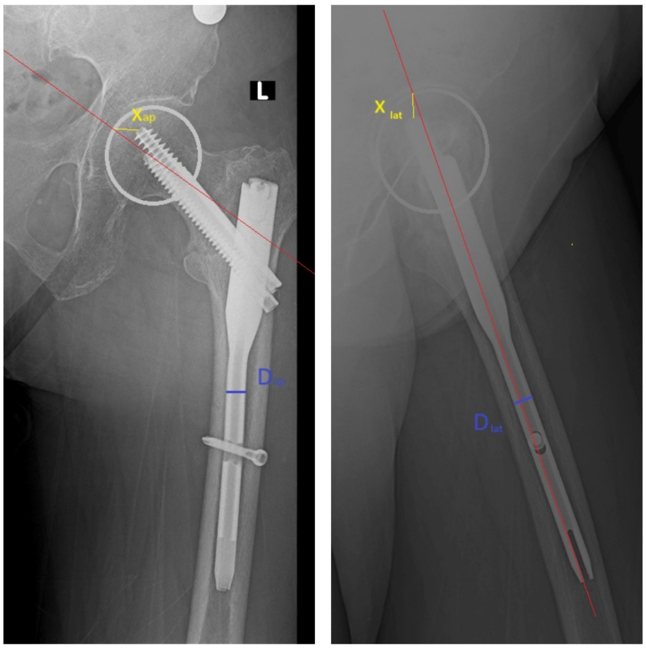


**Figure 2.** Tip-apex distance (TAD) measurement; TAD = (Xap x Dtrue/Dap) + (Xlat x Dtrue/Dlat).

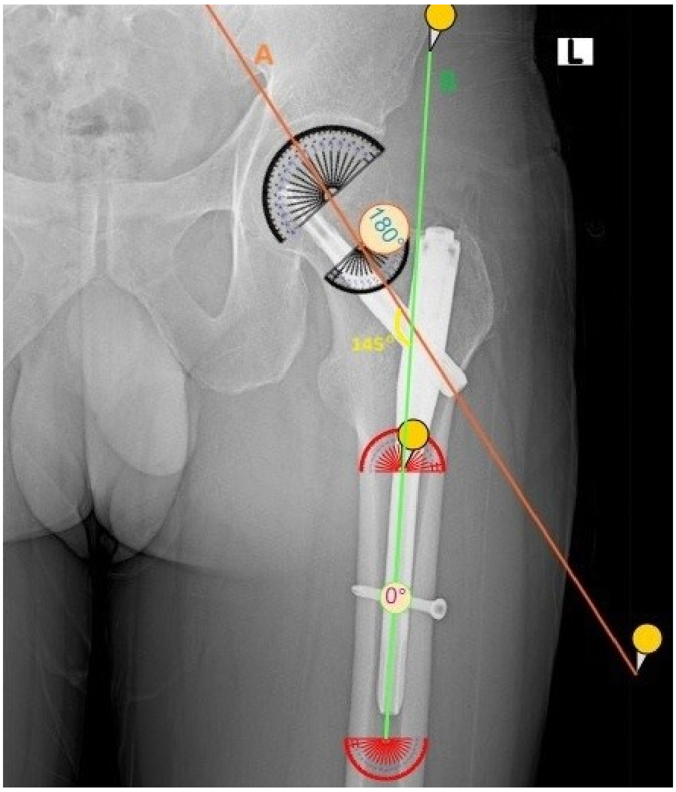


**Figure 3.** Collodiaphyseal angle (CDA) was measured between the line dividing the femoral head and neck into two equal parts and two lines indicating the anatomical axis of the femur.

view, varus angulation less than 20 degrees on the lateral view, and displacement criteria of less than 4 mm were considered indicators of effective reduction [13, 14]. Moreover, the presence of at least one of the aforementioned criteria was considered as acceptable reduction. The CDA was measured between two lines, one dividing the femoral head and neck into two equal parts and the other indicating the anatomical axis of the femur (Figure 3).

*Surgical technique*

After ensuring appropriate anesthesia conditions for patients, standardized surgical techniques were employed for all patients within the first 48 hours following the trauma. In order to standardize fracture reduction and stabilization among patients, only those who underwent spinal anesthesia were included in the study, while patients undergoing general anesthesia were not included. This decision was made because under spinal anesthesia, there is complete inhibition of muscle tone, which eliminates the influence of muscle forces (such as hip external rotators, iliopsoas, etc.) on fracture reduction [15]. All patients were positioned in lateral decubitus with the assistance of fluoroscopy-guided entry via a guide wire inserted from the tip of the greater trochanter. Following the placement of the nail under fluoroscopic control, the lag screw was aimed to be positioned one-third caudal to the femoral neck on AP radiographs and centralized on lateral radiographs, while TAD was aimed to be kept below 25 mm on both AP and lateral radiographs. Subsequently, static locking was achieved with the assistance of a distal screw. The lag screw was locked to the nail using a locking screw (end cap) proximal to the nail.

*Postoperative protocol*

Patients were mobilized with the assistance of a walker within 48 hours following surgery, once their postoperative vital signs were stable. Joint movements were not restricted. Wound dressings were changed every two days, and stitches were removed on the 15th postoperative day. Venous thromboembolism prophylaxis with low molecular weight heparin was administered for 30 days postoperatively. Patients were advised to attend follow-up clinic appointments at three and six months postoperatively.

*Statistical analysis*

Descriptive statistics were reported, including the mean and standard deviation for continuous variables, along with the median and minimum-maximum values. In the power analysis, when type 1 error: 0.05 and efficacy power: 0.80 were predicted, a statistically significant minimum of 34 patients were needed in both groups. The Kolmogorov-Smirnov test was utilized to evaluate the normal distribution of continuous data. It was observed that continuous variables in both groups did not follow a normal distribution, and the assumption of significant difference between the two groups was tested using the Mann-Whitney U test.For qualitative variables, the chi-square test or Fisher's Exact test was employed. Significance testing comparing pre- and post-measurements was conducted using appropriate statistical methods. The significance level was set at a p value $< 0.05$ for all tests.

## Results

Out of the 85 patients who met the inclusion criteria, 44 were in the PFNA group and 41 were in the Intertan group. In the PFNA group, the mean age was 75.1 $\pm$ 8.2 years (range: 65–96), and in the Intertan group, it was 76.4 $\pm$ 7.3 years (range: 65–89), with no significant difference observed between the two groups (p=0.322). The Female/Male ratio in the PFNA group was 21/23, while in the Intertan group, it was 25/16, and no significant difference was observed between the groups (p=0.221). Regarding the AO/OTA classification, in the PFNA group, 23 patients had type 31A2 fractures and 21 patients had type 31A3 fractures, while in the Intertan group, 17 patients had type 31A2 fractures and 24 patients had type 31A3 fractures, with no significant difference between the groups (p=0.318) (Table 1).

The mean operation time was 67.0 $\pm$ 12.2 minutes in the PFNA group and 65.0 $\pm$ 7.0 minutes in the Intertan group, with no significant difference observed between the two groups (p=0.184). Regarding the mean hospital stay duration, it was 3.7 $\pm$ 0.8 days in the PFNA group and 3.5 $\pm$ 0.8 days in the Intertan group, with no significant difference observed between the groups (p=0.178). Additionally, there was no significant difference observed in the postoperative 6-month Harris hip scores between the PFNA group (81.8 $\pm$ 7.7) and the Intertan group (81.36 $\pm$ 5.1) (p=0.484) (Figure 4).

**Table 1.** Comparison of parameters between the PFNA and Intertan groups.

| Parameter | PFNA ± SD (Median-Min-Max-IR) | Intertan ± SD (Median-Min-Max-IR) | p value |
|---|---|---|---|
| Age | 75.93 ± 5.91 (75.50-66-87-9.00) | 74.78 ± 3.08 (75.00-68-79-5.00) | 0.419[a] |
| Female/Male | 21/23 | 25/16 | 0.221[b] |
| AO/OTA classification | | | |
| 31A2 | 23 | 17 | 0.318[b] |
| 31A3 | 21 | 24 | |
| Operation time (mins) | 62.86 ± 4.27 (63.00-54-70-4.75) | 64.68 ± 3.97 (65.00-56-72-5.50) | 0.03[a] |
| Hospital stay (days) | 3.59 ± 1.10 (3.00-2-6-1.75) | 3.56 ± 1.14 (3.00-2-6-1.00) | 0.784[a] |
| Harris hip score | 81.84 ± 7.73 (81.50-61-96-12.25) | 81.36 ± 5.10 (81.00-71-89-8.00) | 0.484[a] |
| Reduction quality | | | |
| Good | 26 (59.1%) | 19 (46.3%) | 0.239[b] |
| Acceptable | 18 (40.9%) | 22 (53.7%) | |
| Parker Index Non-acceptable | 13 (29.5%) | 11 (26.8%) | 0.781[c] |
| Collodiaphyseal angle | 137.25 ± 7.02 (136.50-124-151-12.00) | 136.07 ± 4.82 (136.00-125-144-7.00) | 0.348[a] |
| Tip-apex distance (mm) | 18.45 ± 7.7 (17.50-7-37-9.75) | 18.5 ± 6.7 (17.00-3-36-11.00) | 0.781[a] |
| Union rates | 84.09% | 97.5% | 0.008[c] |
| Reoperation rates | 15.90% | 4.87% | 0.158[c] |

[a]: Mann Whitney U test, [b]: Chi-squared test, [c]: Fisher's exact test, SD: Standard deviation, IR: Interquartile Range, mins: minutes, mm: milimeter.

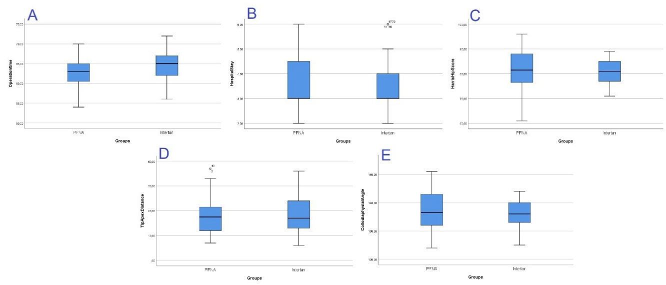


**Figure 4.** Graphical representation of continuous variables (Operation times (A), Hospital stays (B), Harris hip scores (C), tip-apex distances (D) and collodiaphyseal angles (E)).

When postoperative radiographic measurements were examined, it was observed that among the 44 patients in the PFNA group, 26 (59.1%) had good reduction, while 18 (40.9%) had acceptable reduction. In the Intertan group, out of 41 patients, 19 (46.3%) had good reduction, and 22 (53.7%) had acceptable reduction. Statistical analysis revealed no significant difference between the two groups in terms of this aspect (p=0.239) (Table 1).

In the postoperative X-ray evaluations, according to the PI assessment, it was observed that in the PFNA group, the implant was in an inappropriate position in 13 patients. Specifically, in AP radiographs, the implant was positioned superiorly in 7 patients, while in lateral radiographs, the lag screw was centrally located in 8 patients, and in 2 patients, it was in an inappropriate position in both planes (AP and lateral). In the Intertan group, the implant was found to be in an inappropriate position in 11 patients, with 7 patients having the lag screw positioned inferiorly or centrally in AP images, 5 patients having the lag screw not centrally positioned in lateral images, and 1 patient having the implant not appropriately positioned in both planes (AP and lateral). However, according to the PI assessment, no statistically significant difference was observed between the two groups (p=0.781) (Table 1).

In the PFNA group, the CDA measured on postoperative X-rays was 137.25 ± 7.02 (ranging from 124 to 151), while in the Intertan group, it was 136.07 ± 4.82 (ranging from 125 to 144), with no significant difference observed between the two groups (p=0.348). In the early postoperative radiographs, the mean TAD (tip-apex distance) measurement in the PFNA group was 18.45 ± 7.7 mm (ranging from 7 to 37 mm), with TAD measurements exceeding 25 mm observed in 8 patients. The mean TAD for these 8 patients was 31.7 ± 3.8 mm (ranging from 27 to 37 mm). In the Intertan group, the mean TAD was 18.5 ± 6.7 mm (ranging from 6 to 36 mm), with TAD distances exceeding 25 mm observed in 7 patients. The mean TAD for these 7 patients was 29.1 ± 3.2 mm (ranging from 26 to 36 mm). There was no significant difference observed in TAD measurements between the two groups (p=0.781), and although the number of patients with TAD measurements exceeding 25 mm was higher in the PFNA group, this difference was not statistically significant (p=0.893) (Figure 4).

Union rates and reoperation rates were evaluated in both groups. In the PFNA group, union was observed in 37 patients by the end of the 6th month. However, cut-out occurred in 7 patients, leading to reoperation with endoprosthesis. In the Intertan group, union was observed in 40 patients, and cut-out occurred in 1 patient, necessitating reoperation with endoprosthesis. Significant higher union rates were observed in the Intertan group (p=0.008). Additionally, in one patient from the Intertan group, union was achieved, but reoperation was required due to skin irritation caused by the compression screw (the implant was removed). There was no significant difference in reoperation rates between the two groups (p=0.158) (Figure 4).

It was observed that all 8 patients who experienced cut-out among all patients had the implant inadequately positioned according to the PI and had a TAD above 25 mm. There was a significant difference between the rates of cut-out occurrence in patients with improperly positioned implants in the PFNA group (7 patients, 53%) compared to the Intertan group (1 patient, 9%) (p=0.033). Additionally, there was a significant difference between the rates of cut-out occurrence in patients with TAD above 25 mm in the PFNA group (7 patients, 27.5%) compared to the Intertan group (1 patient, 14.2%) (p=0.01) (Table 1).

## Discussion

This study aimed to comprehensively compare the radiological and clinical performances of two commonly used intramedullary implants for the treatment of unstable intertrochanteric fractures in a single center using a retrospective approach. Similarities were observed between the two groups in terms of operation duration, length of hospital stay, Harris Hip scores at postoperative 6 months, reduction quality, PI, CDA, TAD, and rates of reoperation. The two main differences observed between the groups were the higher union rate in the Intertan group and the shorter operation time in the PFNA group (p=0.008, p=0.03, respectively). Other significant differences identified between the two groups included a higher rate of cut-out in the PFNA group among patients with TAD measurements above 25 mm (27.5%, 7 patients) compared to the Intertan group (14.2%, 1 patient). Similarly, the rate of cut-out was significantly higher in patients with improperly positioned implants according to the PI in the PFNA group (53%, 7 patients) compared to the Intertan group (9%, 1 patient) (p=0.03). This suggests that in cases of improperly positioned implants, Intertan nails maintain fracture reduction more stably compared to single-blade nails and can tolerate this stability better. The underlying reason for this is the biomechanically superior design of Intertan nails. Aside from this parameters, when we looked at the overall comparison between the groups, we observed that all parameters were similar. These results support the conclusion that both nails can be safely used for intertrochanteric fracture fixation with appropriate fracture reduction and placement.

Trochanteric fractures are more commonly seen in the geriatric population following low-energy trauma [16, 17]. With increasing life expectancy, orthopedic surgeons encounter these fractures more frequently in their daily practice. Early mobilization in the geriatric population is critical to reduce comorbidities, and it is equally important to maintain stable fracture fixation during this mobilization [18, 19]. There was no significant difference in cost as the costs of both implants were very close to each other. Literature reports have indicated that intramedullary implants provide biomechanically stable fixation in the treatment of intertrochanteric fractures [20-22]. With advancements in technology in medicine, various PFNs have been designed and used in practice. Among these nails, PFNA and Intertan nails, which are third-generation PFNs, are commonly preferred today. Numerous studies have compared both PFNA and Intertan nails with other nails in terms of clinical and biomechanical performance, but a consensus on which one is the gold standard has not been reached [23-26]. In a study by Duramaz et al. examining 203 intertrochanteric fracture patients, they reported that the mean operation time, duration of fluoroscopy, blood loss, and TAD parameters were longer in Intertan nails compared to PFNA nails [25]. At the end of the study, it was reported that PFNA nails were superior to Intertan nails in terms of surgical parameters, clinical outcomes, and radiological results. However, in a more comprehensive meta-analysis study examining 20 studies involving 1015 patients conducted by Yu et al., it was reported that both nail types had similar clinical outcomes, but Intertan nails provided a more rigid fixation against rotational and axial forces [27]. They reported that this rigid fixation resulted in a lower complication rate due to the advantage of early mobilization and advocated for the use of Intertan nails.

TAD value was initially defined by Baumgaertner and colleagues, who reported that when this value exceeds 25 mm, the risk of cut-out increases [13]. Caruso et al., in a study involving 571 patients with a follow-up of over 6 years, evaluated various parameters besides cut-out and found that TAD remained the most accurate predictor for cut-out risk [28]. Fuji et al. also assessed different parameters for cut-out risk, including the OTA/AO classification of the fracture, presence of posterolateral fragment in the fracture, types of reduction patterns on AP and lateral radiographs, position of the screw, and a distance of $\geq$20 mm from the tip of the screw to the apex [29]. Among these factors, they associated a TAD of $\geq$20 mm with cut-out in intertrochanteric fractures treated with PFNA systems. Therefore, we also examined TAD as one of the radiological parameters. When comparing between the two groups, we found that TAD distance was above 25 mm in 13 patients in the PFNA group and 11 patients in the Intertan group, with no significant difference. However, the rate of cut-out was significantly higher in patients with TAD above 25 mm in the PFNA group (p=0.033). This indicates that the Intertan nail provides a more rigid fixation and is therefore biomechanically superior. Additionally, the need for secondary surgery due to cut-out and implant failure was significantly higher in the PFNA group (p=0.008).

Since our study was retrospective, intraoperative fluoroscopy images were not evaluated. However, in a previous study, it was found that the gap distance between the proximal and distal fragments in trochanteric fractures was larger in PFNA compared to Intertan nails [23]. This finding suggests that Intertan nails may provide more effective compression during surgery and that the PFNA device has a lower capacity to reduce the fracture gap. With this feature, Intertan nails provide a more rigid fixation, allowing for early loading and faster union. This correlates with the higher union rates observed in the Intertan group in our study. Additionally, the correlation between Intertan nails being more tolerant in cases where TAD is above 25 mm or in cases of improper placement according to Parker indexing supports this finding. Improperly positioned intramedullary nails in the PFNA group may not provide sufficient compression and stabilization along the fracture line, increasing the risk of cut-out.

Our study included unstable hip fractures (AO/OTA 31A2-3, 31A1-3). Two critical points emphasized for the successful osteosynthesis of unstable hip fractures, as important as the choice of implant, are the quality of reduction and the correct positioning of the implant [30-32]. These two factors are closely linked to the experience and skill of the surgeon. In a study by Biber et al., where they examined complications in patients operated on by physicians and residents for 1516 hip fractures, they emphasized that the complication rate was 2.6 times higher in residents for patients aged 71-80 years [33]. In our study, all surgeries were performed by surgeons with at least five years of orthopedic experience. However, surgical experience is undoubtedly critical in the proper placement of the implant. The absence of cut-out and implant failure between PFNA and Intertan nails correlates with the correct placement of the implant.

There are some limitations to our study. These limitations include the retrospective nature of the study, inclusion of a relatively small patient group, surgeries performed by different surgeons, lack of bone densitometry measurements for patients, absence of comparison of body mass index, and lack of examination of long-term postoperative outcomes.

In unstable trochanteric fractures, while PFNA nails may be more practical implants with appropriate reduction and implant positioning, Intertan nails provide a more rigid fixation and stabilization, resulting in higher union rates and lower risk of implant failure, making them implants that can be used safely.

*Ethical approval*

Ethical approval for this study was received from Necmettin Erbakan University Ethics Committee (Decision number: 2023/4683).

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