ORIGINAL ARTICLE

Functional and radiological comparison of three cephalomedullary nails with different designs used in the treatment of unstable intertrochanteric femur fractures of elderly

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ABSTRACT

BACKGROUND: The aim of this study to compare three cephalomedullary nails (CMNs) with different designs in terms of complication, reoperation, implant failure, mortality rates, and functional outcomes in the treatment of unstable intertrochanteric fractures (UIFs).

METHODS: This retrospective study included patients with UIFs (AO/OTA type 31-A2 and 31-A3) who were treated with one of these CMNs (74 patients with Talon-PFN, 70 patients with PFN-III, and 69 patients with Intertan) between October 2014 and October 2018.

RESULTS: A total of 213 patients (122 females and 91 males) with a mean age of 81.0±9.3 years have participated in this study. The mean follow-up time was 26.1±6.3 months. Malfixation was the most common complication and the most common reason of reoperation for each type of CMN. Complication and reoperation rates, post-operative functional status, mean union times, and overall mortality rates were similar between groups. Mean operation/fluoroscopy time and mean blood loss were low in the Talon-PFN group, whereas the highest means of these parameters were in the PFN-III group. There were six (8.2%) implant failures in the Talon-PFN group and one (1.5%) in PFN-III group. No implant failure was seen in the Intertan group. The highest rate (58.6%) of anatomic reduction was detected in PFN-III group.

CONCLUSION: Our study results showed that each implant type had its own advantages and disadvantages in the treatment of UIFs with similar functional and reoperation outcomes. Intertan was advantageous with its absence of implant failures. Talon-PFN decreased the operation/fluoroscopy time and intraoperative blood loss but had the highest implant failure rate. There was a need for more anatomic reduction to centralize two separate parallel lag screws in the femoral neck in PFN-III group, and that costs operation/fluoroscopy time and blood loss. Malfixation, which was the most common cause of complications and reoperations, should be avoided.

Keywords: Cephalomedullary nail; elderly; fracture healing; hip fracture; intertrochanteric fracture; intramedullary nailing; post-operative complications; treatment outcome.

INTRODUCTION

Hip fracture is the third most common fracture in the elderly after vertebra and distal radius fractures, and the most costly and mortal one.[1] Nearly, half of all hip fractures are intertrochanteric (IT) fractures.[2] Global projections estimate that the incidence of hip fractures will continue to rise with the growth of the geriatric and osteoporotic population.[3] Ear-

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ly surgery, followed by early mobilization, is the centerpiece of the IT fracture treatment.[4] There are two alternatives: extramedullary and intramedullary implants (cephalomedullary nails [CMNs]) for surgical treatment. The CMNs have a reduced distance between the nail and hip joint (shorter lever arm) compared to extramedullary implants that have reduced deforming forces around the implant and fracture, leading to better outcomes (shorter operating time, reduced intraoperative blood loss, and improved walking ability) with lower complication rates.[5–8] Therefore, CMNs are found to be the effective and preferred choice for the treatment of IT fractures than extramedullary implants.[9]

Implants used in the treatment of osteoporotic hip fractures undergo change and development over time. There are many types of CMNs in the market according to their femoral neck screw/blade designs: One *(Gamma3 of Stryker, TFN of Depuy Synthes, IMHS of Smith and Nephew)* or two parallel lag screws *(PFN of Depuy Synthes, Profin of TST, PFN-III of Jiangsu Trauhui)*, two parallel or convergent lag screws *(Veronail of Orthofix)*, one lag screw with talons *(Talon DistalFix of ODI-NA)*, one lag screw with wedge wings *(DLT of U &I corp.)*, one perforated blade for cement augmentation *(PFN-A perforated of Jiangsu Trauhui, PFN-A with augmentation option of Depuy Synthes)*, one blade *(PFN-A and PFN-A2 of Depuy Synthes)*, one screw integrated with one blade *(APFN of TST)*, and two integrated interlocking screws *(Intertan of Smith and Nephew)*. Every type of CMN has its own advantages and disadvantages. A comparison of these CMN types in detail will pave the way for a perfect CMN design with lower complication rates.

The Talon DistalFix Proximal Femoral Nail System (Orthopedic Designs North America Inc., FL, USA) is a novel implant that uses an innovative way for locking mechanism by deploying talons at both the distal part of the nail and at the

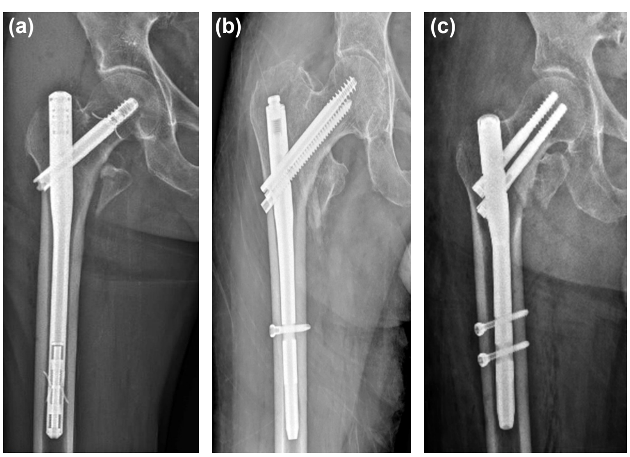

Figure 1. Cephalomedullary nails that are compared in this study. Talon DistalFix Proximal Femoral Nail System (*Orthopedic Designs North America Inc.*, FL, USA) (Left). Trigen-Intertan Intertrochanteric Antegrade Nail *(Smith and Nephew Inc., Memphis, Tennessee, USA)* (Middle). Proximal Femoral Nail-III *(Jiangsu Trauhui Medical Instrument Co., Changzhou, China)* (Right).

lag screw. Intertan Nail (Smith and Nephew Inc., Memphis, Tennessee, USA) is also a revolutionary implant in terms of integrated interlocking two lag screws and trapezoidal nail shape. Proximal Femoral Nail-III (Jiangsu Trauhui Medical Instrument Co., Changzhou, China) has unique features such as the threaded design of the nail-lag screw junction and the use of a fastening screw and nuts inside the lag screw to lock the lag screw to the nail to prevent mediolateral migration. These three CMNs are demonstrated in Figure 1.

There are many reports about the clinical and radiological outcomes of Intertan in the literature.[10] However, there are limited reports about Talon-PFN, and there is no report of PFN-III.[11,12] The advantages of these different designs of CMNs against each other have not been evaluated in the literature. In our study, we aimed to compare the reoperation, implant failure, complication and mortality rates and functional results obtained with three CMNs with different designs that were commonly used in the treatment of unstable IT fractures.

MATERIALS AND METHODS

This study was performed under the approval of our institution's ethical review board (Document number: 33216249-903.99-E.14485) and was conducted in accordance with the Declaration of Helsinki. Informed consent was obtained from each participant before the operations. The clinical records of patients who underwent osteosynthesis for IT fracture between October 2014 and October 2018 were reviewed retrospectively. Patients older than 60 years with the diagnosis of unstable intertrochanteric fractures (UIFs) (AO 31-A2, 3), who underwent fracture fixation using Talon-PFN, PFN-III, and Intertan were included in our study. There were 301 patients with UIFs treated with three different types of CMNs in this period. The choice of each CMN that was used during the study period was dependent on the availability of these devices at our university hospital during the interventions. Orthopedic implants in our country are provided in state hospitals according to the national rules of tender regulated by law. Thus, there was no time when all three CMNs were available at the same time during the study period. There was one of the CMNs at a time. Therefore, the decision regarding the choice of either Talon-PFN or PFN-III or Intertan was not based on any patient or fracture characteristics. The exclusion criteria were the following: Pathological fractures (n=3), polytrauma fractures (n=7), previous surgery of the ipsilateral limb (n=5), advanced hip osteoarthritis (n=6), and inability to walk before the injury (n=9). Eleven patients who were lost to follow-up and 38 patients who died within the first 3 months after the operation were also excluded from the study because of the inability to achieve bone union. Bedridden patients were excluded because of the fact that the fracture and the implanted CMNs did not undergo the same weight-bearing stress that walking patients withstand, which may lead to complications/failure. In addition, we faced severe osteoporosis that may be a disadvantage resulting in implant failure and cutout in these patients. Therefore, we did not include these patients. Patients operated with open reduction (n=9) were also excluded from the study. Because open reduction would affect the surgical time and the blood loss between CMNs. Thus, a total of 213 patients have participated in this study.

Implants and Surgical Technique

Table 1 presents the features of the implants. The operations were performed on the fracture table with traction under fluoroscopic guidance. The surgical techniques of these three implants are similar to those of other commonly used CMNs.

Postoperative Follow-up

All patients were allowed weight bearing as tolerated using a walker on the 1st postoperative day and underwent the same rehabilitation program. Patients were followed up in the outpatient clinic at 4-week intervals until the bone union was achieved and then were followed up annually. Fracture healing was assessed radiologically. Radiological fracture healing was defined as the presence of a bridging callus on at least three of four cortices (on anteroposterior [AP] and lateral hip radiographs). The radiographical assessment was performed before and after the operation and also at the time of follow-up.

Data Evaluation

Patients' demographic data (age, gender) as well as follow-up time, mechanism of injury, type of anesthesia, and American Society of Anesthesiologists' classification were recorded. Perioperative variables, such as duration of surgery (minutes), intraoperative blood loss (milliliters), length of hospital stay (days), time to bone union (months), and all complications, were noted.

The Salvati-Wilson hip score was used to assess clinical function by four parameters: pain, walking ability, muscle power–motion, and function (32–40 points = excellent, 24–31 points = good, 16–23 points = fair, and 0–15 points = poor).[13] Preoperative scores were obtained at the interview with the patient and/or relatives. Post-operative scores were obtained at the 12th month and annual follow-ups.

The quality of the fracture reduction was assessed by three criteria. The anatomic neck-shaft angle should be between 125° and 135° on the AP view (1). The anterior or posterior angulation should be <20° on the lateral view (2). The cortical

Table 1. Features of the implants

Features	Talon-PFN	Intertan	PFN-III
Alloy	Titanium	Titanium	Titanium
Lateral bend angle	4°	4°	5°
Neck angle	120°–130°	125°–130°	130°
Length (mm)	220–420	180–460	200–240
Proximal diameter (mm)	15.5	15.25x16.25	
Distal diameter (mm)	11	10 to 13	10–12
Lag screw length (mm)	70–120	Superior screw: 70 –125 Inferior compression screw: 65–120	65–125
Lag screw diameter (mm)	Thread:11 Root: 8.2	Superior lag screw: 11 Inferior compression screw: 7	6.5
Integral lock	Yes	Yes	Yes
Integral locking mechanism	Set screw from the proximal tip of the nail	Set screw from the proximal tip of the nail	Compression nut/end nut inside the lag screws, Fastening screw from the proximal tip of the nail, Lag screws adhere to the nail with the help of the threads both on the screw and inside the nail
Maximum deployable Talon diameter (mm)	Lag talon: 28 Distal talon: 38	–	–
Number of Talons	Lag talon:4 Distal talon: 6	–	–

congruence at the calcar region should be restored, and the displacement of the fracture (distraction or translation at the fracture site, in any direction) should be ≤4 mm (3).[13–15] This measurement was scaled on the distal diameters of the nails, which is known to be 11 mm for Talon-PFN or PFN-III and 11.5 mm for Intertan, to standardize measurements among different radiographs. If these three criteria were fulfilled, anatomic reduction was defined. When fewer than three criteria were met, the reduction was labeled as nonanatomic. The ideal position for the neck screws was slightly inferior to the center for Talon-PFN on AP view, central for Intertan, and the radiolucent sloth between the screws should be central for PFN-III. Central position was the ideal position for all three CMNs on the lateral view.

Complications were classified as general, local, and technical. Technical complications consisted of malfixation (malposition of the femoral neck screw(s), varus/valgus malreduction of the fracture), cutout, avascular necrosis (AVN), heterotopic ossification, and implant failure (bending/breakage of the implant, failed talon deployment, failure of integral locking mechanism). General complications involved pneumonia, mental confusion, urinary tract infection, decubitus ulcer, pulmonary thromboembolism, deep venous thrombosis, stroke, and myocardial infarction. Hematoma, superficial wound infection, prolonged wound discharge, and deep infection were defined as local complications. Malposition of the neck screw is defined as inappropriately long screws (juxta-articular but just inside femoral head cortex) or screws with a tip-apex distance (TAD) >25 mm[16] or superior or inferior placement of the screws. For Intertan and PFN-III, TAD is measured from the upper screw.[17] The failure of integral locking mechanism was examined with two subheadings: Lateral migration of neck screw and reverse Z-effect.

Statistical Analysis

Statistical analysis was performed using SPSS 25.0 (SPSS Inc., IBM, NY, USA). Numerical variables were represented as means and standard deviations, and categorical variables were provided as frequencies and percentages. One-way analysis of variance was used to compare continuous data (means) between groups. Tukey's post hoc analysis was used for multiple comparisons of significant results. Bonferroni's correction method was used in the adjustment for multiple comparisons. A Chi-square test was used to test differences between observed frequencies. A p<0.05 was considered statistically significant.

RESULTS

A total of 213 patients (122 females and 91 males) with a mean age of 81.0±9.3 years have participated in this study. The mean follow-up time was 26.1±6.3 months. The mean hospitalization time was 7.4±3.2 days, and the mean time to fracture union was 13.9±2.6 weeks. No nonunion was observed during follow-up. Table 2 represents the main clinical characteristics of the patients. Most of them were similar between groups. Statistically significant differences between groups were observed in terms of the mean operation time, mean fluoroscopy time, mean intraoperative blood loss, and ratios of reduction type (p<0.01, p<0.01, p<0.01, and p=0.04, respectively). Talon-PFN was found to have the shortest mean operation, fluoroscopy times, and the least intraoperative blood loss. PFN-III had the highest ratio of anatomic reduction.

Table 3 represents all complications, post-operative functional scores, and mortality rates. Technical/general/local complications, reoperation, mortality rates, and post-operative functional status were found to be similar between the three groups. The most common complication observed was malfixation. Varus malreduction was found to be more frequent than valgus. Cutout rates were similar between groups. All of the patients with a cutout (4 patients) had an initial varus malreduction and a TAD >25 mm at the same time (Fig. 2). Patients with valgus malreduction did not have a cutout. The only reverse Z-effect was from the PFN-III group. There were two AVNs in the Talon-PFN group (Fig. 3). There were six (8.2%) and one (1.5%) implant failures in the Talon-PFN and the PFN-III groups, respectively. No implant failure was observed in the Intertan group. The reasons for implant failure were found to be bending/breakage of the nail from the neck screw junction (one patient in the Talon-PFN group did not agree for reoperation with CMN exchange and providentially healed with hypertrophic callus), failed femoral neck talon deployment (three patients in the Talon-PFN group healed uneventfully), and failure of integral locking mechanism (two patients in the Talon-PFN group had lateral migration of the neck screw <5 mm and healed uneventfully, one patient in the PFN-III group had reverse-Z effect revised with total hip arthroplasty [THA]) (Fig. 4).

There were four (5.5%) patients in the Talon-PFN group who had undergone reoperation (THA) because of cutout

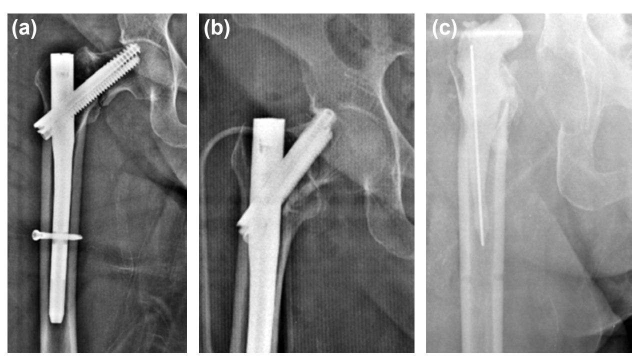

Figure 2. Catastrophic result of a varus malreduction. Initial varus malreduciton with a TAD of 33 mm **(a)** followed by varus collapse and cutout **(b)**. The patient did not agree with the reoperation proposal of hip replacement. Later, due to the deep infection with a fistula at lateral thigh, implant removal, fistula excision, soft tissue and bone debridement, femoral head extraction, and spacer with vancomycin implantation were performed **(c)**.

Table 2. Main clinical characteristics of the patients

	Talon-PFN	Intertan	PFN-III	p	Test
Number of patients	74	69	70		
Mean age (years)	81.8±8.9	79.8±9.3	81.0±9.6	0.45	Anova
Mean follow-up (months)	24.4±5.1	25.7±5.9	26.1±6.3	<0.01	Anova
Gender, n (%)				0.95	Chi-square
Male	31 (41.9)	29 (42)	31 (44.3)		
Female	43 (58.1)	40 (58)	39 (55.7)		
BMI (kg/m^2)	24.8±2.0	24.7±2.1	24.5±2.2	0.73	Anova
Mechanism of injury, n (%)					
Domestic fall	74 (100)	69 (100)	70 (100)		
Other	0 (0)	0 (0)	0 (0)		
Fracture type (AO/OTA classification), n (%)				0.84	Chi-square
31-A2	66 (89.1)	61 (88.4)	64 (91.4)		
31-A3	8 (10.9)	8 (11.6)	6 (8.6)		
ASA classification, n (%)				0.98	Chi-square
ASA 1	11	11	10		
ASA 2	23	20	24		
ASA 3	40	38	36		
ASA 4	0 (0)	0 (0)	0 (0)		
Preoperative functional status*, n (%)				0.99	Chi-square
>31 excellent	16 (21.6)	15 (21.7)	13 (18.6)		
24-31 good	30 (40.5)	27 (39.2)	28 (40)		
16-23 fair	26 (35.2)	24 (34.8)	27 (38.6)		
<16 poor	2 (2.7)	3 (4.3)	2 (2.8)		
Hospitalization time (days)	7.2±3.1	7.5±3.3	7.4±3.1	0.92	Anova
Type of anesthesia, n (%)				0.38	Chi-square
General	3 (4.1)	5 (7.3)	7 (10)		
Spinal	71 (95.9)	64 (92.7)	63 (90)		
Mean operation time (min)	40.4±4.9	52.2±5.6	62.2±5.7	<0.01	Anova
Mean fluoroscopy time (s)	27.9±5.8	36.7±8.1	45.9±10.6	<0.01	Anova
Mean intraoperative blood loss (ml)	128.7±13.3	208.1±21.4	212.2±24.2	<0.01	Anova
Type of reduction, n (%)				0.04	Chi-square
Anatomic	28 (37.9)	30 (43.5)	41 (58.6)		
Non-anatomic	46 (62.1)	39 (56.5)	29 (41.4)		
Mean union time (weeks)	13.5±2.7	14.0±2.6	14.1±2.7	0.36	Anova

*Salvati and Wilson hip score. BMI: Body mass index; ASA: American Society of Anesthesiologists; AO/OTA: The AO Foundation/Orthopaedic Trauma Association.

(two patients) and AVN (two patients). Two patients (2.9%) had undergone nail removal and debridement with antibiotic (Vancomycin) spacer implementation in the Intertan group because of deep infection with a sinus tract. Soft tissue debridement was performed in one patient with hematoma and prolonged wound discharge, whereas two patients had to undergo THA surgery as a result of a cutout (1.5%) and a reverse Z-effect (1.5%) in the PFN-III group. The reverse Z-effect was a result of integral locking mechanism failure. Nearly, 50% of the patients had at least one complication without any statistically significant difference between groups (p=0.93). Reoperation rates were low (below 6%) despite these high rates of complications without any statistically significant difference between groups (p=0.75).

More than 60% of patients in each group had reached the 1st year after the CMN surgery to compare post-operative functional assessment. No statistical difference was found among

Table 3. Complications, reoperation, postoperative functional status, and mortality

	Talon-PFN		Intertan		PFN-III		p	Test
Technical complications	**n**	**%**	**n**	**%**	**n**	**%**		
Malfixation	28	37.9	23	33.4	23	32.9	0.78	Chi-square
Malposition of femoral neck screw(s)	14	19.0	17	24.7	20	28.6		
Malreduction of the fracture	14	19.0	6	8.7	3	4.3		
Varus malreduction	9	12.2	5	7.3	2	2.9		
Valgus malreduction	5	6.8	1	1.5	1	1.5		
Cutout	2	2.8	1	1.5	1	1.5	0.81	Chi-square
Avascular necrosis	2	2.8	0	0	0	0		
Heterotophic ossification	1	1.4	1	1.5	1	1.5	0.99	Chi-square
Implant failure	6	8.2	0	0	1	1.5		
Bending/breakage of implant	1	1.4	0	0	0	0		
Failed talon deployment of the lag screw	3	4.1	–	–	–	–		
Fail of integral locking mechanism	2	2.8	0	0	1	1.5		
Lateral migration of the lag screw(s)	2	2.8	0	0	0	0		
Reverse Z effect	0	0	0	0	1	1.5		
Total	39	52.8	25	36.3	26	37.2	0.07	Chi-square
General complications								
Pneumonia	4	5.5	7	10.2	6	8.6		
Urinary tract infection	7	9.5	8	11.6	5	7.2		
Decubitus ulcers	10	13.6	3	4.4	5	7.2		
Mental confusion	14	20	10	14.5	11	15.8		
Pulmonary thromboembolism	0	0	1	1.5	1	1.5		
Deep venous thrombosis	0	0	1	1.5	1	1.5		
Myocardial infarction	0	0	2	2.9	1	1.5		
Stroke	0	0	1	1.5	3	4.3		
Total	35	47.3	33	47.9	33	47.2	0.99	Chi-square
Local complications								
Superficial infection	1	1.4	0	0	1	1.5		
Hematoma	1	1.4	2	2.9	1	1.5		
Prolonged discharge	0	0	0	0	1	1.5		
Deep infection	0	0	2	2.9	0	0		
Total	2	2.8	4	5.8	3	4.3		
Patients with at least one complication	40	54.1	35	50.8	37	52.9	0.93	Chi-square
Reoperation								
Total hip arthroplasty	4	5.5	0	0	2	2.9		
Nail removal and debridement with antibiotic spacer implementation	0	0	2	2.9	0	0		
Only soft tissue debridement	0	0	0	0	1	1.5		
Total	4	5.5	2	2.9	3	4.3	0.75	Chi-square
Postoperative functional status*								
>31 excellent	2	3.8	5	9.6	4	7.6		
24–31 good	14	26.0	15	28.9	14	26.4		
16–23 fair	21	38.8	18	34.6	21	39.6		
<16 poor	17	31.4	14	26.9	14	26.4		
Total	54	100	52	100	53	100	0.92	Chi-square
Mortality								
In hospital	7	8.3	10	12.2	8	9.6	0.64	Chi-square
First 3 months	11	13.0	13	15.9	14	16.7	0.69	Chi-square
One-year	31	36.5	30	36.6	31	37.0	0.99	Chi-square
Two-year	46	54.2	43	52.5	45	53.6	0.97	Chi-square

*Salvati and Wilson hip score. PFN: Proximal femoral nail.

Figure 3. A very rare complication of intertrochanteric fracture fixation: AVN of the femoral head. Early post-operative **(a)** and 1st-year radiographs **(b)** after Talon-PFN fixation.

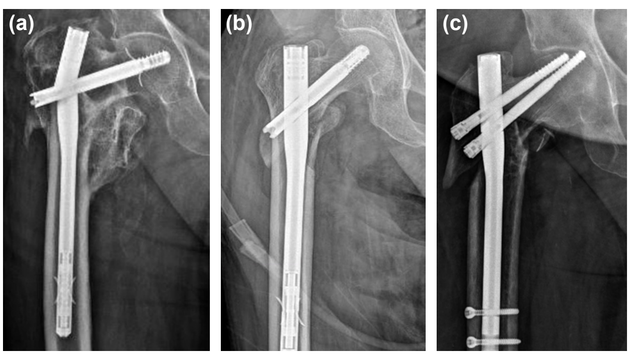

Figure 4. Different types of implant failures. Bending/breakage of the Talon-PFN implant from the neck screw-nail junction **(a)**, fail of lag screw talon deployment of the Talon-PFN **(b)**, and reverse Z effect (lateral migration of superior screw with a cutout of the inferior screw) due to the fail of the integral locking mechanism of the PFN-III **(c)**.

the three groups of patients (p=0.92) in terms of post-operative functional status. The rates of reaching preoperative functional status were around 40% and found to be similar between groups (p=0.92). Two-year mortality rates were about 53% and were similar between groups (p=0.97).

Among fracture reductions, the most difficult ones were the reductions of AO 31-A3 fractures, especially the reverse oblique type. However, we were able to manage the reduction by closed means with the help of Schanz screws, T-handle, and ball-tipped pusher. We experienced that AO 31-A3 fractures were more prone to varus malreduction than AO 31-A2 fractures.

DISCUSSION

Each CMN type (Talon-PFN, Intertan, and PFN-III) has its own advantages and disadvantages in the treatment of UIFs. This is claimed to be the most important finding of this study. Most of the main clinical characteristics, functional and radiological outcomes were observed to be similar between groups. We think that the general and local complication rates, mortality and reoperation rates, and functional outcomes were similar because all fractures were fixed by closed reduction. Probably for the same reason, fracture union was observed in all patients. Differences were observed between groups in terms of the mean operation time, mean fluoroscopy time, mean intraoperative blood loss, type of reduction, and implant failure rates. We attribute these differences to the different design of the implants.

The reported overall complication rate of UIF fixation with various kinds of CMNs is up to 48%–53% in the literature.[11,18] The rates of patients with at least one complication (Talon-PFN: 54.1%, Intertan: 50.8%, and PFN-III: 52.9%) were similar to the reported series, and these high rates are attributed to the detailed manner of this study. Reported reoperation rates had reached up to 13.8%, and reoperation rates of this study (Talon-PFN: 5.5%, Intertan: 2.9%, and PFN-III: 4.3%) were within this limit.[19] Although nonunion rates after CMN fixation vary between 1% and 5%, bone union was achieved in all fractures in our study.[20]

One of the main mechanisms of fixation failure is cutout, which is defined as the protrusion of the lag screw out of the femoral head. The rates of cutout in our study (Talon-PFN: 2.8%, Intertan: 1.5%, and PFN-III: 1.5%) were similar to the literature that vary between 4% and 20%.[5,21–25] The reasons of a cutout are listed as osteoporosis, UIFs, malfixation (varus [>5°] or valgus [>15°] malreduction of the fracture and superior malposition of the lag screws), lateral wall fracture, fractures with a posteromedial fragment, residual gapping (>3 mm) at basicervical component, and TAD >25 mm by previous studies.[26–29] Of these reasons, malfixation was observed to be the most common complication encountered in one-third of patients in each group of our study (Talon-PFN: 37.9%, Intertan: 33.4%, and PFN-III: 32.9%). There are a few reports of malfixation in the literature, and the incidence varies between 10% and 50%.[11,26,30] This wide range has been attributed to the detail levels and different malfixation criteria of the studies. The rates of malfixation in our study are within this limit. In the Talon-PFN group, two out of nine patients (22.3%); in the Intertan group, one out of five patients (20%); and in the PFN-III group, one out of two patients (50%) with varus malreductions had cutouts. Initial varus malreduction accompanied with a TAD greater than 25 mm followed by varus collapse was reported to be the main reason for the cutouts and reoperations (four [44.5%] out of nine reoperations) in this study. Malfixation (the most common complication and the most common reason for reoperation in this study) is a surgeon-related problem (rather than an implant-related problem) and should be avoided.

Talon-PFN had shorter operation and fluoroscopy times and lesser blood loss. It is evident that novel talon design is useful in these terms by easy distal talon deployment by eliminating the need for distal locking and its incision. Lag screw talon locking comes in handy as it bypasses the second lag screw placement for rotational stability. However, the more complex the design of an implant becomes by adding new features, the greater is the risk of implant failures. Each implant failure offers an opportunity to correct its flaws. Although the implant failure rate of the Talon-PFN was relatively high (8.2%), none of these failures led to reoperation. Among Talon-PFN's implant failures, the most glaring one was the bending/breakage of the implant (1.4%) of which providentially achieved bone union was with hypertrophic callus. The patients with failed talon deployment of the lag screw (4.1%) and lateral migration (<5 mm) of the lag screw (2.8%) also healed uneventfully. The only implant failure (1.5%) of the PFN-III caused a reverse Z-effect because of the failure of the integral locking mechanism, which was critical in avoiding mediolateral migration of screw(s) and revised to arthroplasty. Intertan had no implant failures.

PFN-III had achieved a more anatomic reduction with a rate of 58.6%. This was because a more anatomic reduction was needed to introduce two separate parallel lag screws through the femoral neck. However, more anatomic reduction means more reduction time and more operation and fluoroscopy time with more blood loss.[10] Even though the patients implanted with PFN-III had achieved a higher rate of anatomic reduction, no difference was found between groups in terms of mean union time, post-operative functional status, and complications.

AVN was detected twice in our UIF fixation series with Talon-PFN, which is rare, with an incidence of 0.3–1.37%.[31–33] More studies are needed to determine whether the talon deployment of the lag screw impairs the circulation of the femoral head.

In the literature, the rate of restoration of preoperative mobility and functional status was between 40% and 50% of patients treated with a CMN.[34] The rates of restoration in this study (Talon-PFN: 40.8%, Intertan: 46.2%, PFN-III: 41.6%) were in accordance with the literature without significant difference between groups (p=0.83).

The major limitation of this study was its retrospective design. Prospective randomized controlled trials with high rates of follow-up are essential to get really good information comparing different implants. The retrospective setting comes with a number of substantial flaws as it's difficult to standardize the treatment protocol, follow-up routine, and compare the patients' functional status. However, the retrospective design of the study prevented potential patient and CMN design selection bias. In addition, we evaluated a nonrandomized patient group operated in different time periods with various CMN designs. The demographics, as well as clinical fracture types of the groups, were similar, which demonstrated that we compared a relatively homogenous patient group operated with three different CMN designs. Another limitation of this study is that approximately 60% of the patients reached the 1st-year follow-up due to the high mortality rate, which is the time of functional assessment. Therefore, functional assessment with 60% of the total patient population makes the comparison of functional results less representative. Results may be affected by the learning curve of using multiple implants. Malfixation is a surgeon-related complication rather than being implant-related. General complications are unlikely to be influenced by CMN design.

It is the largest case series in the literature with Talon-PFNs and the first series that reports PFN-III results. This is considered as the main strength of this study. Besides, this study is the first in the literature that reports this combination of CMNs that have different lag screw designs with integral locking mechanisms (talon lag screw vs. integrated interlocking lag screws vs. dual separate lag screws) and also complications and clinical and radiological outcomes in a very detailed design.

Conclusion

Although each design had its advantages/disadvantages, three CMNs had comparable complication rates and clinical and radiological outcomes according to the results obtained in this study. The Talon-PFN had shorter operation/fluoroscopy times and reduced intraoperative blood loss. The Intertan was without implant failures. The highest rate of anatomic reduction rate was achieved with PFN-III. They can be considered as suitable alternatives in the treatment of UIFs. Malfixation was the most common complication and should be avoided.

Ethics Committee Approval: This study was approved by the Erzincan Binali Yildirim University Clinical Research Ethics Committee (Date: 20/03/2020, Decision No: 03/10).

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ORİJİNAL ÇALIŞMA - *ÖZ*

Yaşlılarda instabil intertrokanterik femur kırıklarının tedavisinde kullanılan dizaynları farklı üç sefalomedüller çivinin fonksiyonel ve radyolojik açıdan karşılaştırılması

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AMAÇ: İnstabil intertrokanterik kırıkların (İİTK) tedavisinde kullanılan farklı tasarımlara sahip üç sefalomedüller çivinin (SMÇ) komplikasyon, reoperasyon, implant yetersizliği, mortalite oranları ve fonksiyonel sonuçları açısından karşılaştırılmasıdır.

GEREÇ VE YÖNTEM: Bu geriye dönük çalışma, Ekim 2014 ile Ekim 2018 yılları arasında bu SMÇ'lerden biriyle (Talon-PFN: 74 hasta, PFN-III: 70 hasta ve Intertan: 69 hasta) tedavi edilmiş İİTK'lı hastaları (AO/OTA tip 31-A2 ve 31-A3) içermektedir.

BULGULAR: Çalışmaya yaş ortalaması 81.0±9.3 yıl olan toplam 213 hasta (122 kadın ve 91 erkek) katılmıştır. Ortalama takip süresi 26.1±6.3 aydır. Malfiksasyonun, herbir SMÇ tipi için en sık komplikasyon ve reoperasyon nedeni olduğu görülmüştür. Komplikasyon ve reoperasyon oranları, ameliyat sonrası fonksiyonel durum, ortalama kaynama süreleri ve genel mortalite oranları gruplar arasında benzer bulunmuştur. Ortalama operasyon/floroskopi süresi ve ortalama kan kaybı Talon-PFN grubunda düşük iken, bu parametrelerin en yüksek ortalamaları PFN-III grubundaydı. Talon-PFN grubunda altı (%8.2) ve PFN-III grubunda bir (%1.5) implant yetersizliği mevcuttu. Intertan grubunda hiç implant yetersizliği görülmemiştir. En yüksek anatomik redüksiyon oranı (%58.6) PFN-III grubunda tespit edilmiştir.

TARTIŞMA: Çalışma sonuçlarımız, İİTK'ların tedavisinde benzer fonksiyonel ve reoperasyon sonuçlarına sahip olmakla beraber her bir implant tipinin farklı avantaj ve dezavantajlara sahip olduğunu göstermiştir. Intertan, implant yetersizliği olmamasıyla avantajlıdır. Talon-PFN ameliyat/floroskopi süresini ve intraoperatif kan kaybını azaltmakla beraber en yüksek implant yetersizliği oranına sahiptir. PFN-III'ün iki ayrı paralel boyun vidasını femur boynunda merkezi yerleştirebilmek için daha fazla anatomik redüksiyona ihtiyaç duyduğu ve bunun operasyon/floroskopi süresinin uzamasına ve kan kaybının artmasına sebep olduğu görülmüştür. En sık komplikasyon ve reoperasyon sebebi olan malfiksasyondan kaçınılmalıdır.

Anahtar sözcükler: Ameliyat sonrası komplikasyonlar; intertrokanterik kırık; intramedüller çivileme; kalça kırığı; kırık iyileşmesi; sefalomedüller çivi; tedavi sonuçları; yaşlılar.

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