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Original Article

Which implant is better for beginners to learn to treat geriatric intertrochanteric femur fractures: A randomised controlled trial of surgeons, metalwork, and patients

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ABSTRACT

Background: We wondered whether the third-generation gamma nail-3 (GN-3) was better for junior surgeons to learn to treat geriatric intertrochanteric femur fractures than proximal femoral nail antirotation-II (PFNA-II).
Methods: This is a prospective randomised study of 350 patients who underwent GN-3 fixation and PFNA-II carried out by junior orthopaedic trauma surgeons from January 2011 February 2017. We compared nail positioning, complication rates, operative and fluoroscopy time, blood transfused, time to mobilisation, hospital stay, fracture union, mismatch, mortality and postoperative outcomes. The minimum follow-up was 12 months (mean, 27.2 months; range, 12–42 months).
Results: The recovery rate of the GN-3 group was higher than that of the PFNA-II group significantly. Compared with the PFNA-II group, the GN-3 group was superior in fracture gap, while operative time, fluoroscopy time, blood transfused, time to mobilisation, hospital stay, Harris Hip Score, reoperation, mortality and so on had no significant difference between two groups. There were five cases with cutout through the femoral neck in the GN-3 group, whereas in the PFNA-II group, we only had two cases with significant difference. The area of match in the GN-3 group conformed to that of the femur of Asian population better than that in the PFNA-II group.
Conclusions: PFNA-II and GN-3 internal fixation are both effective methods for junior orthopaedic trauma surgeons to treat femoral intertrochanteric fracture. But our study reveals better results of the GN-3 group over the PFNA-II group on recovery rate. There is a high rate of cutout in patients treated with the GN-3, especially for those with bone defect or serious osteoporosis.
The translational potential of this article: The results of this work have the potential to improve the cognition of geriatric intertrochanteric femur fractures for junior surgeons, supplying the theoretical basis for the selection and comparison of Intramedullary nail. Such a guidance will allow better healing, fewer complications, and ultimately improved outcomes.

Introduction

More than a decade ago, intramedullary nailing systems were introduced as a treatment alternative for geriatric intertrochanteric femur fractures (GIFFs) [1]. Gamma nail and proximal femoral nail antirotation have come out consecutively, which made early full weight-bearing and mobilisation possible [1–3]. These derivative techniques have been attracting much attention because of superior biomechanically. But, to date, the choice of surgical treatment of GIFFs continues to be a major concern [4]. The theoretical advantages of the nail include percutaneous insertion and restoration of the biomechanical property [5]. The third-generation gamma nail (GN-3; Stryker, Mahwah, New Jersey) and proximal femoral nail antirotation-II (PFNA-II; Synthes GmbH, Oberdorf, Switzerland) are widely used as the latest versions [6]. Both blade and screw designs have fewer complications and lower reoperation rates than reported in the literature [7,8].

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Nowadays, as a tertiary trauma centre and teaching affiliated hospital, most GIFFs are operated by young junior orthopaedic trauma surgeons. They often face with a situation on how to choose the proper intramedullary fixation. Ultimately, they would pick seemingly the simple one or something superior surgeons recommended. However, as a matter of fact, there is still little evidence that which one is the preferred choice for junior surgeons. Most previous studies just compared the outcomes of different implants in intertrochanteric fractures, and these operations were mostly performed by some senior surgeons [6]. Furthermore, almost all publications neglected the relationship between the surgeons and the metalwork. The adaption of different implants varies from surgeon to surgeon. It is also increasingly important to know the results from the junior surgeon's work. Only by combining the three factors, surgeon, metalwork, and patient into an organic whole, can the best effect be achieved.

Therefore, we designed this study by randomising junior surgeons who began to learn to treat GIFFs, implants, and patients. Specifically, we determine whether there is a difference of intraoperative and postoperative patients' variables between implants and surgeons. The question arises whether the GN-3 is better for junior surgeons to learn to treat GIFFs compared with the PFNA-II nail.

Patients and methods

Materials and preoperative preparation

From January 2011 to February 2017, we conducted a prospective randomised study to compare the operation-related indexes between GN-3 fixation and PFNA-II by junior orthopaedic trauma surgeons who first learnt to treat GIFFs. The institutional review board approved this study. Informed consent was obtained from the patients or their relatives if the patients were incapable of consent. Patients who were admitted to our hospitals (The First Affiliated Hospital of Soochow University; Jinling Hospital; Fuzhou Second Hospital affiliated to Xiamen University) with a trochanteric fracture during the study period were considered eligible for the study. A total of 32 orthopaedic trauma fellows who just finished their residency training were allocated to perform the operation independently. They were not supervised by senior surgeons intraoperatively because they had already completed one-year orthopaedic trauma residency training and cadaver workshops of both implants. All these 32 less experienced residents, familiar with both implants and procedure details, were defined as beginners because they did not performed the operations independently before. Besides, subsequent patients were excluded if these junior surgeons have performed the surgery over 2 years.

Patients ineligible for the study presented one or more of the following: younger than 60 years; not available for examination in outpatient clinic because of residing in other provinces or countries; a previous hip fracture on the affected site; multiple fractures; confinement to a bed (nonambulatory patient); a pathologic fracture; subtrochanteric fracture; limited life expectancy because of significant medical comorbidities [American Society of Anesthesiologists (ASA) Grades IV and V]; or a reverse obliquity fracture. There were 415 patients compliant with the inclusion criteria after the screening. Of these, we excluded 9 patients because of the loss of follow-up and 56 because of accidental death within one year. Remaining 350 patients were treated by the 32 junior orthopaedic trauma surgeons, using either the GN-3 (n = 169) or PFNA-II (n = 181). The recordings were digitised and archived in their files, including clinical and radiologic history, type of injury, bone mineral density (BMD), comorbidity, details of operation, and regular follow-up. BMD was measured on bilateral hip joints and lumbar vertebra by dual energy X-ray absorptiometry before operation. In accordance with the Orthopaedic Trauma Association (OTA) classification system, we classified these fractures into stable types (e.g., A1 AO/OTA classification) and unstable types (e.g., A2, A3 AO/OTA classification) [9]. The duration of follow-up amounted to 27.2 months on average (range, 12–42 months). General data about age, sex, side, body mass index, ASA, BMD, type of fracture, timing of the day demarcated by out of office (5:30 PM), and comorbidity were summarised in Table 1. There was no statistical difference between the two groups.

Table 1
Demographics and comorbidities.

Variable	GN-3	PFNA-II	*p* value
Age (years)	77.47 ± 7.33	77.19 ± 8.45	0.062
Sex (number of males/Females)	74/95	78/103	0.877
Side (number on right/left)	98/71	109/72	0.403
Body mass index (kg/m2)	20.68 ± 2.76	20.77 ± 2.77	0.727
ASA score	2.21 ± 0.43	2.26 ± 0.45	0.079
Type of fracture A1/A2 (AO classification)	64/105	80/101	0.229
Timing of the day (day time/ night time)	119/50	120/61	0.099
BMD	−2.09 ± 0.49	−2.10 ± 0.51	0.641
Comorbidity			
Hypertension and cardiovascular diseases	87	101	0.170
Sequelae of cerebral infarction	27	23	0.151
Diabetes mellitus	41	38	0.229
Chronic renal insufficiency	11	15	0.102

All qualitative variables are presented as numbers except age, body mass index, ASA score, and BMD, which are presented as mean ± SD.
ASA = American Society of Anesthesiologists; BMD = bone mineral density; GN-3 = third-generation gamma nail; PFNA-II = proximal femoral nail antirotation-II; SD = standard deviation.

Surgical procedure

Surgery was performed in 2–6 days after patients admitted to the hospital. General anaesthesia and spinal anaesthesia were used in both groups. All patients were performed in the supine position on traction table, which made the injured slightly adducted to facilitate insertion of the nail. All surgical procedures were carried out with internal fixation (GN-3 and PFNA-II) based on the standard protocols, and, if possible, closed reduction was given priority under C-arm fluoroscopy. The PFNA-II nail used in the present study was available in various different sizes (9, 10, 11, or 12 mm in diameter and 170, 200, 240 mm long). The GN-3 had a proximal end—170, 240, 260 mm long—and 10 mm at the distal end, except that type of 180 mm long had a diameter of 11 mm. When working length was unacceptable (at least 5 cm from distal fracture line), a long GN-3 (240 or 260 mm) and a long PFNA-II nail (200 or 240 mm) were used for those with significant subtrochanteric extension [10]. The nails were inserted on the top of greater trochanter and distal interlocking was positioned in a static manner. Intramedullary reaming was performed for all patients who underwent long-nail fixation but not for all patients who underwent short-nail fixation, except for those with narrow circumference of the femoral medullary cavity or nail insertion was difficult intraoperatively. Details of operation were collected, including quality of reduction, fracture gap, lateral wall fragment, closed/open reduction, nail length, mismatch, tip–apex distance (TAD), operation, and fluoroscopy time. We classified quality of reduction into four categories: excellent—anatomical reduction; good—up to 5 degrees of varus or valgus on the anteroposterior view or 5 degrees of anteversion or retroversion on the lateral view or up to 5 mm of translation between the main fragments; accepted—up to 10 degrees of varus–valgus or anteversion–retroversion and up to 10 mm of translation between the main fragments; and unaccepted—not to the level of functional reduction [11]. The fracture gap was measured at the first postoperative anteroposterior and lateral radiographs, classified as good—0–3 mm; accepted—3–5 mm; poor—> 5 mm [6]. Calculation of TAD was accomplished using Baumgarten formula by measuring the distance between the tip of the proximal screw/blade to the apex of the femoral head on the anteroposterior and lateral radiographs.

Postoperative management and follow-up

These patients received prophylactic intravenous antibiotics starting 1 h before operation. Postoperatively, chemical venous thromboembolism prophylaxis (weight-adjusted doses of Fraxiparine) was adopted. Regardless of any fracture type and different internal fixation, all patients complied with the same rehabilitation protocol [12]. The active part or full weight-bearing should be performed gradually as tolerated thereafter. In addition, the two groups were compared regarding time to mobilisation, number of units of blood transfused, and length of hospitalisation.

Follow-up occurred at 1, 3, 6 months and one year after operation. Plain anteroposterior and lateral radiographs were obtained at each visit, which were used to observe fracture healing (fracture union or implant failure). All radiographs were evaluated at the end of the study by one observer (Dr. Yingjie Xu), who was blinded to the outcome. The in-house standard of fracture union was determined as follows: no local tenderness; no abnormal local activity; radiographic blurred fracture line, and continuous callus. Every patient was required to fill out questionnaire on the Harris Hip Score to evaluate the function of hip joint at 6 and 12 months. We defined "Harris 12 months > 80" as standard recovery [11]. All hip and thigh pain, complications, nonunion, and reoperation were on record.

Statistical analysis

All data were analysed using the SPSS statistical package (IBM SPSS Version 20.0 (IBM Corp, Armonk, NY, USA)) and represented as mean and standard deviation (SD) for continuous response variables or numbers and percentages for discrete variables. The independent samples *t* test was used for analysis of continuous variables, such as age, body mass index, ASA score, and so on. We determined differences in discrete variables such as the type of fracture using the chi-square test and column variables (quality of reduction and fracture gap) using the Kruskal–Wallis test. The Fisher test was calculated to determine differences concerning qualitative variables. The level of significance was established at $p \leq 0.05$ for all tests.

Results

Compared with the GN-3 group, the operating and fluoroscopy time seemed to be shorter in the PFNA-II group. However, the difference between them turned out to be not significant. Furthermore, we also observed no significance regarding blood units transfused, time to mobilisation, hospital stay, and some operative values, including quality of reduction, lateral wall fragment, reduction, and so on. Most lateral wall fragments caused by insertion of the nail occurred intraoperatively and were minor splits of lateral cortex, which was acceptable and healed with delayed full weight-bearing. It was worth mentioning that similar results were obtained in quality of reduction and TAD between two groups, whereas the difference in fracture gap and mismatch revealed that the GN-3 has better performance than PFNA-II for junior surgeons.

Interestingly, when we used "Harris 12 months > 80" as the standard of recovery, the results suggested that patients treated with the GN-3 likely had higher recovery rate than the PFNA-II, despite no difference on the Harris Hip Score. From the perspective of persisting pain, there was no significant difference between postoperative thigh and hip pain. The number of complications and reoperation was measured, and no significant differences were noted. In addition, we identified two nonunions/delayed union in the GN-3 group, which was similar to that in the PFNA-II group (3 cases). They underwent secondary surgeries to achieve union. As for mortality, during hospitalisation, four patients died. Three of them had acute pulmonary embolism or heart failure, and one had multiple organ failure. Taking one-year mortality into consideration, we found that different devices did not influence the end results ($p = 0.567$). Intraoperative and postoperative clinical data were showed in Table 2.

Table 2
Intraoperative and postoperative clinical data.

Variables	GN-3	PFNA-II	*p* value
Details of surgical treatment			
Time of operation (minutes)	66.96 ± 15.63	63.79 ± 14.02	0.137
Fluoroscopy time (seconds)	52.49 ± 25.42	47.27 ± 24.88	0.421
Quality of reduction (excellent/good/accepted)	81/74/14	72/87/22	0.090
Fracture gap (<3 mm/ 3–5 mm/>5 mm)	112/50/7	85/81/15	<0.001*
Lateral wall fragment (n, %)	22 (13.0%)	21 (11.6%)	0.422
Closed reduction (n, %)	145 (85.8%)	159 (87.8%)	0.259
Limited open reduction (n, %)	24 (14.2%)	22 (12.2%)	0.259
Nail length (≤180 mm/≥ 200 mm)	129/40	132/49	0.144
Mismatch (n, %)	43 (25.4%)	55 (30.4%)	0.040*
TAD	24.77 ± 5.07	21.81 ± 5.27	0.625
Time to mobilisation	2.36 ± 1.40	2.31 ± 1.28	0.360
Blood units transfused	261.27 ± 175.12	244.86 ± 150.24	0.084
Hospital stay, median (days)	12.80 ± 4.03	12.35 ± 4.18	0.477
Outcome of evaluation			
Harris Hip Score at 6 months	72.37 ± 9.25	73.03 ± 9.47	0.644
Harris Hip Score at 12 months	84.41 ± 8.23	82.98 ± 9.32	0.479
Hip and thigh pain (n, %)	39 (23.1%)	38 (21.0%)	0.349
Complications related to fixation (n, %)	15 (8.9%)	12 (6.6%)	0.116
Reoperation (n, %)	14 (8.3%)	12 (6.6%)	0.240
Recovery rate (Harris 12 months > 80) (n, %)	140 (82.8%)	142 (78.5%)	0.038*
Nonunion or delayed union	2 (1.2%)	3 (1.7%)	0.456
Mortality			
In-hospital mortality (n, N)	2 (201)	2 (214)	0.900
One-year mortality (n, N)	24 (193)	28 (209)	0.567

All qualitative variables are presented as numbers or numbers (percent) except TAD, blood units transfused, Harris Hip Score, time of operation, fluoroscopy, hospitalisation, and mobilisation, which are presented as mean ± SD.
Note: N represents the total case number including those lost to follow-up and died by the end of hospitalisation or one year.
Abbreviations: GN-3 = third-generation gamma nail; PFNA-II = proximal femoral nail antirotation-II; TAD = Tip-apex distance; SD = standard deviation. *$p < 0.05$.

Of 27 patients suffering complications related to fixation, 15 were in the GN-3 group and 12 were in the PFNA-II group. The total occurrence rate of complications, including cutout, periprosthetic fracture, redisplacement, tractus irritation, implant breakage and loosening, was roughly 7.7%. The cutout of the blade was noted in seven cases (5 in the GN-3 group and 2 in the PFNA-II group; $p = 0.013$). Instead, other complications regarding periprosthetic fracture, redisplacement, implant breakage, and loosening were relatively rare and did not differ substantially between the two groups (Table 3). It was worth mentioning that tractus irritation was in a high proportion of complications in the GN-3 group, but without reaching a significant difference. In terms of periprosthetic fracture, two patients in the PFNA-II group suffered periprosthetic fracture due to postoperative accidents and the others were caused by fall after bony union, all of whom were treated with short nails.

Table 3
Complications related to fixation.

Complication	GN-3	PFNA-II	*p* value
Cutout	5	2	0.013*
Implant breakage	1	2	0.299
Implant loosening	2	2	0.891
Periprosthetic fracture	1	3	0.061
Redisplacement	2	1	0.202
Tractus irritation	4	2	0.069

GN-3 = third-generation gamma nail; PFNA-II = proximal femoral nail antirotation-II. *$p < 0.05$.

These cases were treated successfully with long nails and plating instead. In addition, two cases of implant breakage in the PFNA-II group occurred with a fall at one year after surgery (breakage site at the opening for the blade) and one in the GN-3 group felt sudden pain without any injury at postoperative 11 months (breakage site at the opening for the lag screw). Their common characteristic was the sign of delayed union or nonunion with no evidence of loosening. Concerning the cutout, these cases were managed by revision surgery (hip replacement).

Four main areas of mismatch between the femoral medullary cavity and the nails occurred frequently in the early detection, including lateral side of the proximal part, medial side of cortex in the middle, and mediolateral and lateral area of the distal nail end. The visible mismatches on the radiograph were found in 98 cases (43 in the GN-3 group and 55 in the PFNA-II group) from a total of 350, and many patients had multiple mismatches. As assessed by the observer, nearly 54% (53/98) involved abutment at the area of the distal nail end. The rate of mismatch of mediolateral and lateral area in the PFNA-II group was unusually higher than that in the GN-3 group, comparable with the other two areas (Table 4).

Discussion

The incidence rate of intertrochanteric fractures continued increasing year by year, which occurred mainly in elderly individuals with osteoporosis [13]. Surgical treatment with early mobilisation has become a standard procedure in an effort to keep the overall postoperative morbidity low [8]. In the consideration of surgical practices of junior orthopaedic trauma surgeons, the PFNA-II and GN-3 internal fixation were, no doubt, best suited for them to treat intertrochanteric fracture in the easiest possible way. However, as the theoretical and clinical levels varied from individuals, learning curves were different. Thus, our study was initiated to compare the differences between the PFNA-II and GN-3 groups and to help junior orthopaedic trauma surgeons choose a suitable implant to fix intertrochanteric fractures.

Intramedullary fixation (for example, PFNA and GN) is a minimally invasive method for treating intertrochanteric fractures, which can provide a rapid and stable fixation allowing early mobilisation with full weight-bearing [8,14]. But some intraoperative complications, such as lateral wall fracture caused by impingement of the nail on the proximal lateral cortex, were major problems especially in infancy [15]. To achieve easier accessibility and lower reoperation rate, to date, their designs have been modified twice to overcome those concerns dramatically [11]. For example, the mediolateral angle of the PFNA-II nail is reduced to 5°, allowing a slightly more lateral entry point through the tip of the greater trochanter. Furthermore, it has a more flattened lateral surface that theoretically decreases the length of the region of impingement on the lateral cortex to reduce the risk of fracture during insertion. The similar changes of the modified lag screw and downsizing of the nail constitute the actual GN-3 nail [5]. These evolutions of the design enable junior surgeons to complete the operation.

A large majority of senior surgeons may consider that there is no clear difference between PFNA and GN in terms of success rate, according to their experience [6]. Indeed, part of our data coincides with their thoughts. From our results, the mean operative time, fluoroscopy time, and blood loss seemed to be higher than those in the previous reports [6,14,16]. Actually, we found that many junior surgeons would repeat reduction or manipulation unconsciously during surgery regardless of setbacks, perhaps as a result of low confidence. This will undoubtedly increase operative and fluoroscopy time and intraoperative blood loss, especially for unstable type and subtrochanteric extension. Repeated manipulation also can influence the quality of reduction more or less. However, from our observation, the excellent and good rate reached up to 91.7% and 87.8%, respectively. These data no longer lags behind other study [6,17]. Of course, the aforementioned are not enough to adequately evaluate their intraoperative behaviour. Split of the lateral cortex of the proximal femur was another frequent problem in the course of using devices. It was often seen that the nail was hammered into the marrow cavity without enough reaming, especially for residents, which can lead to high rate of lateral wall fragment, open reduction, and poor implant position. During operation, residents would find it difficult to insert the nail completely, even though the lateral wall thinned with repeated reaming. But this situation will not be affected by the choice of devices according to our results.

During follow-up, patients in both groups had hip and thigh pain, which amounted to approximately 23.1% (GN-3) and 21.0% (PFNA-II). This problem might be attributed to traction during surgery or obturator nerve damage. Another explanation was the inevitable damage of the glutaeus medius when manoeuvring of the nail. In any case, the rate of hip and thigh pain in our report was obviously lower than that in previous research studies [18,19], which for our junior surgeons was to be proud of. Meanwhile, we found that both groups had the similar effects based on the Harris Hip Score. Interestingly, when using "Harris 12 months > 80" as the standard of recovery, results appeared that patients undergoing GN-3 fixation have higher recovery rate than that of PFNA-II. It seemed to imply that GN-3 was better suited for junior surgeons to learn to treat GIFFs.

In terms of complication, all failures, including cutout, periprosthetic fracture, redisplacement, implant breakage, and loosening, occurred after a period of several months of full weight-bearing. To our surprise, our data indicated high probability of cutout for residents in the GN-3 group under the same TAD. Similar conclusion was reported by previous studies [8,11,20,21], and they believed that this complication was associated with the fracture pattern, "Z-effect", poor bone quality, accuracy of fracture reduction, and lag screw position. As assessed by our reviewers, cutout can also occur even when the screw was inserted at an acceptable site. On the one hand, the disadvantage of GN-3 is a lack of bony support on account of drilling of the femoral head, as opposed to PFNA-II, which can preserve maximum bone stocks by compressing the surrounding cancellous bone [22]. On the other hand, a single lag screw affords rotational instability, and the motion of the operated limb leads to loosening of the bone–screw interface, especially for intertrochanteric fracture with bone defect or serious osteoporosis [22]. This sets the stage for the cutout of the screw. But previously mentioned all are outside the control of the surgeon. In view of our research, we emphasise that the surgeon's experience is also an important preventable risk factor because fracture reduction and optimal placement are controlled by the surgeons [23]. For instance, bone loss resulting from repeating drilling misjudgement was also one of the important factors. Also complex types such as subtrochanteric extension fracture may be technically more demanding. It is undeniable that today orthopaedic residents gain less clinical experience than they did in the past, while they are measured by numbers of surgical cases and clinic visits or the breadths of managed clinical problems [24]. Furthermore, the absence of acquaintance of characteristic and indication using devices is another predominant concern. Therefore, regular follow-up with radiological and clinical examination are quite necessary to evaluate fracture healing and implant position for junior surgeons.

Persisting hip and thigh pain in regard to iliotibial tract irritation was detected in around 10.3% of cases in the GN-3 group and 5.3% in the PFNA-II group. Physical examination and radiology proved the relationship between iliotibial tract irritation and screw/blade subsiding/

Table 4
Area of mismatch between the femoral medullary cavity and the nails.

Mismatch	GN-3	PFNA-II	*p* value
Lateral side of the proximal part of the nail	13 (7.7%)	16 (8.8%)	0.257
Medial side of the cortex in the middle	5 (3.0%)	8 (4.4%)	0.054
Distal end of the nail (mediolateral)	22 (13.0%)	31 (17.2%)	0.016*
Distal end of the nail (lateral)	16 (9.5%)	23 (12.7%)	0.026*

GN-3 = third-generation gamma nail; PFNA-II = proximal femoral nail antirotation-II. *$p < 0.05$.

loosening in our report. As previously mentioned, repeated reaming would aggravate the surrounding bony destruction and a smaller contact area. But otherwise, Menezes and Gamulin [23] expounded the importance of overtightening the femoral neck screws, which may result in loss of grip of the screw thread in the osteoporotic bone. To some extent, iliotibial tract irritation, which was rare for experienced surgeons, occurred more commonly in this study. Initial report referenced by Menezes and Gamulin [23] also pointed out that there was an appreciably greater risk of iliotibial tract irritation in surgery performed by residents, in accordance with our thoughts. They believed that meticulous measure and well positioning of screws can avoid the likelihood of it. Overall, these cases relieved the pain eventually after the removal of implant.

There were four cases suffering from periprosthetic fracture owing to positioning error of implant and wrong choice of short cephalomedullary. But, surprisingly, we observed only one typical fracture at a distal positioning of the nail in the GN-3 group postoperatively, while many authors have published that the GN-3 system had higher rate of a secondary femoral shaft fracture [25,26]. Three cases were, by contrast, found in the PFNA-II group, although without reaching a significant difference. But besides experience, mismatch between the femoral medullary cavity and the nails also played a key role in periprosthetic fracture. On the view of matching, the structure at the distal end of the GN-3 conformed to the femur of the Asian population better than PFNA-II according to our study. Theoretically, the distal tip of the PFNA-II nail is biased to the anterior side of the inner cortex so that stress concentration can occur around more easily, making the femoral shaft more vulnerable to fracture compared with the GN-3. However, such a conclusion may not be brought about with regard to our results.

In our report, within the observation period, having excluded the effect of comorbidities [27], in-hospital mortality and one-year mortality were not affected by the qualifications of the surgeons. Hospital mortality and one-year mortality in the GN-3 group was 1.0% and 12.4%, respectively, in comparison with 0.9% and 13.4%, respectively, in the PFNA-II group. These rates were obviously lower than those of other similar reports [14,17,28]. For example, Unger et al. [14] found an in-hospital mortality of 2.0% and a one-year mortality of 15.4% in patients treated with the GN-3. One-year mortality reported by Zhang et al. was up to 13.2% in the study of PFNA-II [17]. But to ensure optimum effect and maximum safety, we had to exclude some patients with high-risk surgery and complex fracture types in the present study, which might influence the final mortality.

In summary, we have compared the capability of the GN-3 and PFNA-II nail, which had become the reference in our department, and no differences were found in the final functional results between the two implants. Nearly 78.5–82.8% of our patients reached their prefracture functional status until the final follow-up. This is an excellent long-term outcome for this age group compared with the literature [6,14,17,29].

There are still some limitations in our study. In consideration of bias and virtual circumstances, subtrochanteric fracture is too difficult to operate and high risk for residents, so that our study only included the patients with A1 and A2 trochanteric fracture types. Consequently, the incomplete data cannot represent the whole clinical parameters. Furthermore, surgical operations are performed by different surgeons, and there are deficiencies in surgical standardisation and proficiency. Outcomes among these orthopaedic trauma surgeons cannot be compared because of the limited cases per fellows. However, from another point of view, the small sample size also reflects that everyone is a beginning learner, which ensures the accuracy of results. Last but not least, collecting comprehensive data prospectively, including InterTan nails and Less Invasive Stabilisation System–distal femur, will be more ideal, which could make conclusion more accurately.

Conclusion

PFNA-II and GN-3 internal fixation are both effective methods for junior orthopaedic trauma surgeons to treat femoral intertrochanteric fracture. Our study reveals that the GN-3 is preferable to PFNA-II on recovery rate. But there is a high rate of cutout in patients treated with the GN-3, especially for those with bone defect or serious osteoporosis.

Highlights

1. PFNA-II and GN-3 internal fixation are both effective methods to treat elderly femoral intertrochanteric fracture for junior orthopedic trauma surgeons.
2. GN-3 have higher recovery-rate than PFNA- II for beginners.
3. The surgeon's experience is still an important factor to prevent postoperative incidence of adverse events.
4. There is a high rate of cutout in patients treated with GN-3, especially for those with bone defect or serious osteoporosis.

Conflicts of interest

The authors have no conflicts of interest to disclose in relation to this article.

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