Observational Study

Medicine

OPEN

Bridged combined fixation system versus locking plate in the treatment of patients with implant periprosthetic refracture following proximal femoral fracture surgery

A retrospective observational study

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Abstract

Locking plate (LP) re-fixation is mainly used to treat postoperative implant periprosthetic refractures; however, the extensive trauma and the fixation form of LP make the operation difficult. The bridge combined fixation system (BCFS) is a new clip-rod internal fixation system, and its clinical application is in its infancy. To compare the clinical effect of BCFS and LP in the treatment of geriatric postoperative implant periprosthetic refracture following proximal femoral fracture surgery. Thirty-two patients (14 with BCFS and 18 with LP) with postoperative implant periprosthetic refracture following proximal femoral fracture surgery, who underwent surgery in our hospital, were analyzed retrospectively. The incision length, operation time, intraoperative bleeding volume, postoperative drainage volume, postoperative hospital stay, fracture healing time and complications of each patient were recorded. Regular radiographs were taken after the operation to evaluate the fracture reduction and fixation. All the patients were followed for 12 months to evaluate their limb function by Johner-Wruhs scoring criteria. The patients were followed for an average of 24.1 months, and all achieved bony union, with no complications such as infection, nonunion, and internal fixation instrument falling off and loosening after the operation. Delayed healing occurred in two cases in the LP group. The average value of surgical incision length, operation time, postoperative hospitalization time and fracture healing time in the BCFS group were significantly smaller than those in the LP group, accompanied by a decrease in intraoperative bleeding and postoperative drainage volumes ($P < .05$). The rate of limb function in the BCFS group (85.7%) was higher than that in the LP group (83.3%), with no significance ($P > .05$). The BCFS in the refracture around the implant of the proximal femoral fracture exhibited many advantages such as simple operation, strong plasticity, effective reduction of surgical trauma, promotion of fracture healing and early functional rehabilitation, etc, making it an advantageous clinical application.

Abbreviations: BCFS = bridge combined fixation system, LP = locking plate, SD = standard deviation, VAS = visual analogue scale.

Keywords: bridge combined fixation system, locking plate, proximal femur fracture, refracture

1. Introduction

With the development of socio-economic levels and the advent of the aging era, proximal femoral fractures, common fractures in the elderly in clinical practice, have also shown a significant upward trend yearly.[1] Total hip replacement to treat femoral neck fracture in the elderly has long been a consensus; in addition, based on the known biomechanical advantages, intramedullary nail fixation is gradually becoming the first choice for treating femoral intertrochanteric fractures.[2] Therefore, there is an ever-increasing incidence of refractures around implants. Vancouver classification method has a good guiding role in treating periprosthetic femur fracture; however, there is no recognized classification methods for intramedullary nail periprosthetic refracture of intertrochanteric fracture of the femur. Researchers[3] have used the Vancouver classification of

This study was supported by Changzhou Sci & Tech Program (Grant No. CJ20220120, CJ20210104), funding from Young Talent Development Plan of Changzhou Health Commission (CZQM2020059) and Changzhou High-Level Medical Talents Training Project (2022CZBJ059 and 2022CZBJ061).

The authors have no conflicts of interest to disclose.

The data sets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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How to cite this article: Zhang J, Xu N, Yang Z, Niu W, Zhou G, Yu Z, Jia X, Zhou X, Huang Y. Bridged combined fixation system versus locking plate in the treatment of patients with implant periprosthetic refracture following proximal femoral fracture surgery: A retrospective observational study. Medicine 2022;101:48(e31538).

Received: 9 January 2020 / Received in final form: 5 October 2022 / Accepted: 5 October 2022

http://dx.doi.org/10.1097/MD.0000000000031538

periprosthetic fractures[4,5] to classify periprosthetic refractures after intramedullary nailing of proximal femoral fractures and adopted corresponding treatment measures accordingly, with satisfactory results. Vancouver B1 fracture is a stable prosthesis fracture, and internal fixation has been given priority as the chief traditional therapeutic regimen.[6] The original fracture heals, while the postoperative intramedullary nail periprosthetic refracture occurs following the proximal femoral fracture surgery. Moreover, Vancouver type B fracture shares the same treatment principle with Vancouver type B1 fracture around the prosthesis.

Locking plates (LP) are commonly used as a salvage device for periprosthetic fractures to avoid more invasive revision replacement procedures. However, extensive trauma, massive blood loss, unmatched internal fixators, fixation difficulties, and other problems occur frequently during reoperation. Wang et al[7] reported a new bridge combined fixation system (BCFS, Figs. 1 and 2), which, as a clamp-locking internal fixation system, has the advantages of external fixation, LPs, and intramedullary nails. In addition to maintaining similar strength to the LP, BCFS can minimize the contact between the internal fixator and the periosteum and increase local bone perfusion. In addition, its most significant advantage is that it can provide multi-angle and multi-directional fixation and facilitate local minimally invasive treatment. The BCSF has gradually shown good clinical effects on irregular lateral bone fractures such as clavicle, pelvis, and metaphysis.[8–11] In our previous retrospective case-control study of mid-clavicular fractures, we validated that BCFS, compared with LP, yielded similar results in functional analysis, fracture healing, and complications.[12]

This retrospective analysis was designed to compare the clinical effects of BCFS and common LP in treating geriatric postoperative implant periprosthetic refracture following proximal femoral fracture surgery.

2. Materials and methods

2.1. General information

Forty-six patients with postoperative implant periprosthetic refracture following proximal femoral fracture surgery were retrospectively analyzed from September 2007 to June 2018. This study was approved by the Institutional Review Board of The Affiliated Changzhou Second Hospital of Nanjing Medical University. All the patients signed informed consent forms.

2.2. Case inclusion and exclusion criteria

Case inclusion criteria: a history of total hip replacement surgery for femoral neck fracture (biological prosthesis) or closed reduction PFNA internal fixation for femoral neck fractures for at least six months, the fracture sites are all implanted or tip, secondary fresh fractures caused by low-energy injuries, and age: >65. Case exclusion criteria: patients having received prosthetic replacement surgery, with loosening and loss of femoral bone component, patients with nonunion, patients with pathological fractures, such as periprosthetic refractures caused by bone tumors; patients with multiple systemic fractures; patients with severe cardiovascular, cerebrovascular, liver, kidney, and central nervous system diseases, who could not tolerate surgery,

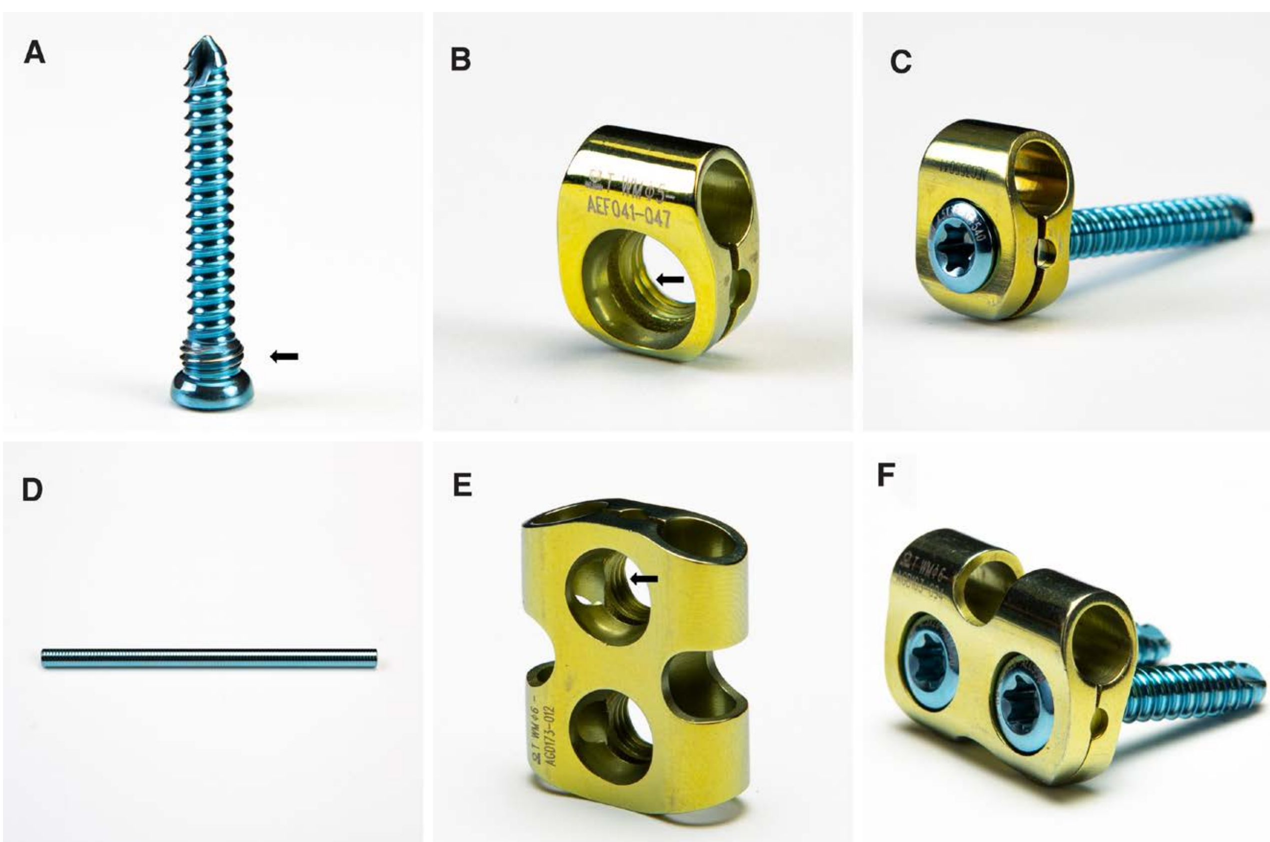

Figure 1. (a) BCFS, which was composed of locking screws, (b and e) bone block, and (d) connecting rod. The bone block could be locked with 1 to 2 screws. (c and f) The arrows showed the locking threads.

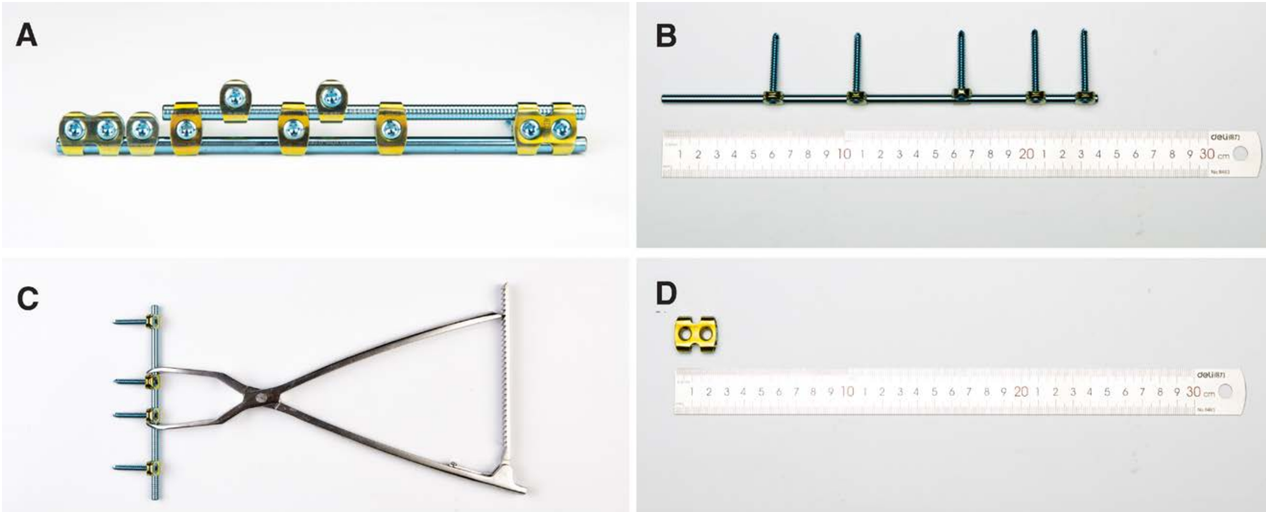

Figure 2. (a) The BCFS system after the composition was completed. (b) The connecting rod could be of different lengths according to requirements, and (d) while the length of the bone blocks was fixed. When needed, axial compression could be performed by pressurized pliers (c).

and open fracture or combined with significant vascular and nerve injury.

2.3. Preoperative preparation

The preoperative examination was completed in all the patients. The fracture type was determined by the preoperative axial position of the hip joint, the lateral position of the femur on the X-ray film, and three-dimensional CT reconstruction. The lower extremity vascular ultrasound was performed before the operation to rule out deep vein thrombosis (DVT). Preoperative evaluations included lung CT, ECG, and cardiac ultrasound and preparation of blood, indwelling catheter, etc. Antibiotics were prescribed 30 minutes before the operation to prevent infection, and the operation was delayed (2-8 days, average: 4.5 days).

2.4. The operative technique

The patients in both groups were treated with continuous epidural anesthesia or nerve block assisted with laryngeal mask general anesthesia. The patients were supine on the traction bed, and the fractures were reduced with the help of a C-arm X-ray machine. In the BCFS (Weiman, China, Figs. 1 and 2) group, several minimally invasive incisions were made outside the thigh according to the screw fixation position determined in vitro. The skin and subcutaneous tissues were cut in turn, and the muscle layer was bluntly separated from the periosteum. The fractured end underwent closed or limited open reduction; the periosteum was preserved as much as possible, the fractured end was reduced and fixed temporarily with reduction pliers, and the fracture reduction was confirmed by C-arm fluoroscopy. Different modules were selected according to different positions of the fracture. Two 6-cm connecting rods with appropriate length were used to insert from one end of the fracture to the other along the lateral periosteal surface or subcutaneously. The connecting rod was shaped slightly, considering the convenience of inserting it if necessary. After confirming that the connecting rod and the module were in a good position through the C-arm perspective, locking screws were used to fix the two ends of the connecting rod, and if necessary, add screws in the middle. When the reduction is difficult, a nail rod can be used to assist in the reduction process. One module and one connecting rod were inserted into the distal and proximal ends of the fracture, and fixed with screws. The sliding between the module and the connecting rod was used to open, pressurize, or rotate to assist in reduction. The larger fracture block can be locked and fixed by a single-hole hook module with a unilateral opening to improve the integrity of the fracture. At least 8 layers of cortical screws were fixed on both sides of the fracture end, and the complex fracture was placed away from the fracture line as far as possible to increase the working length.

The incision in the LP group (Weigao, China or Kanghui, China) was basically the same as that in the BCFS group. A locking compression plate was selected for the proximal fracture, less invasive stabilization system plate was selected for the distal fracture, and the LP was also placed along the periosteum surface through the minimally invasive approach. Limited open reduction was also used to place the plate when the closed reduction was not satisfactory. Because of the locking mechanism of the plate and screw and the very thick LP of the femur, there was no need and no way to shape the plate during operation. Because of the obstruction caused by the implant, the screw was used to only fix the single cortex. If necessary, titanium cable or steel wire was used to assist in fixing the fracture.

Among them, 5 cases in the BCFS group and 6 cases in the LP group underwent allogeneic bone implantation at the fracture end due to fracture comminution. Both groups were treated with conventional negative pressure drainage (Fig. 3).

2.5. Post-operative management

The patients in the two groups were treated with first-generation cephalosporin antibiotics 24 hours after the operation to prevent infection. In addition, they were treated with low-molecular-weight heparin for anticoagulation. Hemoglobin (Hb) levels were monitored after the operation. When Hb level was <70 g/L and blood loss was >800 mL, blood was transfused, and drainage tubes were removed within 48 hours. Twenty-four hours after the operation, the patients were asked to exercise the quadriceps femoris muscle on the bed. At 48 hours, a continuous passive motion (CPM) machine was used for functional exercises, but the affected extremity was forbidden from bearing weight for 6 weeks. The sutures were removed 2 weeks after the operation. The patients were followed for 6 weeks, 12 weeks, 6 months, and 1 year after the operation. The time of fracture healing and complications were recorded. When the X-ray showed that the callus connected the fracture ends, the patient

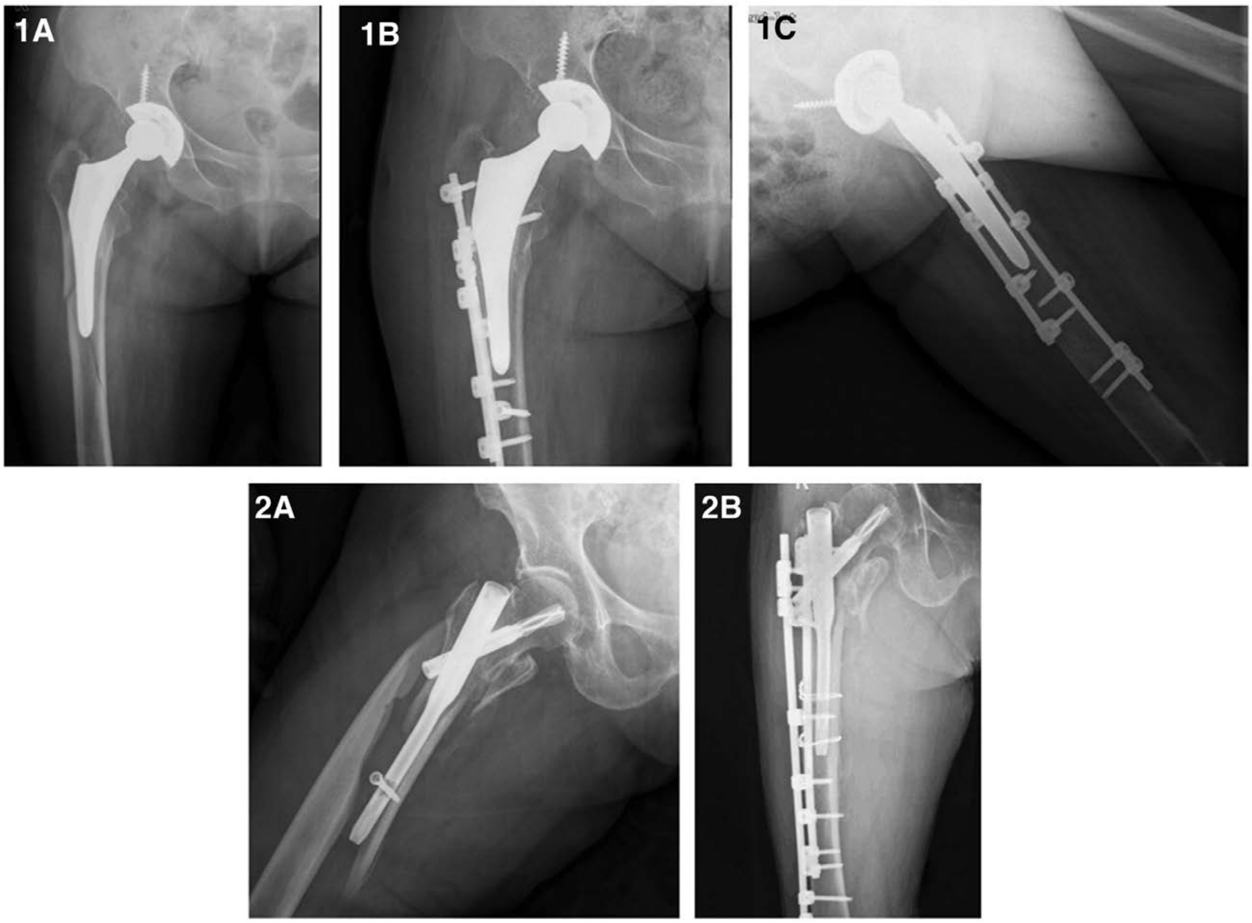

Figure 3. A 78-year-old female patient suffered periprosthetic femoral fractures one year after total hip replacement surgery for a femoral neck fracture due to a fall; (1a) X-ray before operation and (1b and 1c) three months after operation showing that the fracture has been reduced properly and the fracture has healed. An 82-year-old female patient suffered intramedullary nail fractures due to a falling injury after closed reduction and PFNA internal fixation of intertrochanteric fracture of femur; (2a) X-ray before operation and (2b) six months after operation, showing that the fracture has been reduced properly and the fracture has healed. BCFSs (Weiman, China) were used in both cases.

was instructed to start partial weight-bearing, with a gradual transition to full weight-bearing. The X-ray film showed that at least 3 layers of cortical bone were connected to the two ends of the fracture, and the fracture was considered healed when there was no pain under a full complete load.

2.6. Curative effect evaluation

The age, gender, smoking history, fracture displacement, and operation time of the two groups were recorded. In addition, the incision length, intraoperative hemorrhage, operation time, postoperative drainage volume, and postoperative hospital stay were recorded. During the follow-up, regular radiographs were taken to record the patients' fracture healing time and complications. According to the Johner-Wruh evaluation criteria,[13] the patients' limb function was scored 12 months after surgery, divided into excellent, good, moderate and poor as follows:

1) Excellent: fracture healing, normal joint movement, complete resistance; normal gait, no pain, no angular deformity; shortening < 0.5 cm, rotation < 5°; no complications.
2) Good: fracture healing, joint activity > 75%, obvious resistance; normal gait, occasional pain, angular deformity < 5°; shortened 0.5 to 1 cm, rotation 5° to 10°; no infection, rare complication.
3) Moderate: moderate fracture healing, joint mobility > 50%, moderate resistance; limping gait, moderate pain, angular deformity 10° to 20°; shortening 1 to 2 cm, rotation 10° to 20°; no complications such as infection and injury of nerves and blood vessels.
4) Poor: delayed union or nonunion of fracture, joint activity < 50% of normal, lack of resistance; limping gait, pain, angular deformity of bone > 20°; shortening > 2 cm, rotation > 20°; often with infection and other complications.

The following formula was used to calculate the excellent healing rate percentage:

Excellent rate (%) = (patients with excellent limb function score + patients with good limb function score)/total number of patients in each group × 100%.

Visual analogue scale (VAS) pain scores were performed on the first day and at 1-week, 1-month and 3-month postoperative intervals. In addition, patients' subjective satisfaction was recorded at 1-month, 3-month, 6-month, and 1-year postoperative intervals.

2.7. Statistical analysis

SPSS statistics software (version 21.0; SPSS Inc., Chicago, IL, USA) was used for analysis. Continuous data were reported by mean and standard deviations (SD), and classified data was reported by absolute numbers and percentages. Continuous variables were analyzed using the Student *t*-test for normal distribution; otherwise, the Mann–Whitney *U* test was used. The Chi-squared test or Fisher exact test was used to analyze categorical variables. The odds ratio (OR), 95% confidence interval (CI) of binary results, and mean difference (MD) were calculated for continuous results. The difference was considered statistically significant at $P < .05$.

3. Results

3.1. Basic characteristics of included patients

Forty-six patients with postoperative implant periprosthetic refracture following proximal femoral fracture surgery were retrospectively analyzed, including 14 patients in the BCFS group (9 joint replacements, 5 intramedullary nails), 18 patients in the LP group (13 joint replacements, 5 intramedullary nails). In the BCFS group, there were 3 males and 11 females, with an average age of 77.5 years (65-86 years). In the LP Group, there were 4 males and 14 females, with an average age of 79.3 years (67-85 years). There were no significant differences in age, gender, smoking history, and displacement fracture. The patients were followed for 13-50 months, with an average of 24.1 months (**Table 1**).

3.2. Comparison of primary follow-up outcomes

No major vascular and nerve injury occurred during the operation in the two groups. The postoperative incision healed well without infection and exudate. The fracture reduction and fixation were excellent, without complications such as nonunion, leg shortening, internal fixation loosening, and fracture. Compared with the LP group, the average length of the surgical incision, operative time, postoperative hospitalization time, and fracture healing time were shorter in the BCFS group, and the average intraoperative bleeding volume and postoperative drainage volume were significantly lower (Table 2). The VAS scores and satisfaction rates of the two groups were observed in the follow-up period. The BCFS group exhibited less pain than the LP group. However, there was a significant difference in the pain score of the BCFS group only three months after the operation (Table 3), which might be attributed to minimally invasive procedure, periosteal protection, and relatively faster healing in the BCFS group compared to the LP group. However, due to the study's retrospective nature and the small number of included patients, a higher level of evidence is needed to further confirm the conclusion. In addition, in the LP group, one patient developed a hematoma at fracture ends after the operation, which improved after local drainage. There were also two cases with delayed fracture union. After the follow-up observations, one case exhibited bone healing 9 months after the operation. Another case achieved bone healing 10 months after the operation after injecting autogenous bone marrow into the broken end of the fracture 8 months after the operation. One patient in each group suffered from persistent pain in the hip joint (Table 4).

3.3. Functional comparison of affected extremities

The excellent rate of the patients in the BCFS group was higher than in the LP group, but the difference was not statistically significant (Table 5).

4. Discussion

With the increase in human lifespan, femoral neck and intertrochanteric fractures are common hip fractures in the elderly, and the incidence is increasing yearly. The traditional conservative treatment modality has a long treatment period, and patients must stay in bed for a long time. In addition, the incidence of complications is high, and the treatment effect is moderate. Therefore, to help patients tolerate the surgery, it is usually recommended that patients undergo early surgical intervention and reduce patients' recovery time and complications as much as possible. Hip arthroplasty and central fixation, represented by PFNA,[14] are commonly used to treat hip fractures. Over time, the incidence of periprosthetic fractures increases accordingly.[2] In the early stage of implantation, the bio-fixed femoral stem could not be fully integrated with the host bone immediately, forming a stress concentration effect similar to that of the loose stem. Therefore, it has been reported that the postoperative femoral periprosthetic refracture of the uncemented stems mostly occurs about half a year after the prosthetic replacement. Statistics from the Swedish National Artificial Joint Registry show that periprosthetic fractures have become the third leading cause of joint revision after sterile prosthesis loosening and infection, with an incidence of approximately 5%.[15] With the completion of the process of bone ingrowth, the prosthesis and the host bone are well integrated, decreasing the incidence of hip stem periprosthetic fractures.[16,17] The fracture heals half a year after the intramedullary nail fixation operation for intertrochanteric fracture of the femur.

The purpose of managing such fractures is to reconstruct the length and axis of the lower extremity, enabling the patient to restore mobility as soon as possible through fracture fixation.[18] It is helpful to solve this problem by classifying the refracture around the implant. Currently, the most widely used femoral periprosthetic fracture classification system is the Vancouver classification system proposed by Duncan and Masri in 1995. The classification basis is the fracture site, the stability of the prosthesis, and the bone mass of the patient, which is highly reliable and accurate.[19] There is no generally accepted classification method for refractures around postoperative intramedullary nails after femoral intertrochanteric fractures. Li et al[3] referred to the Vancouver classification and tried to reclassify it according to the fracture site around intramedullary nails as follows:

Table 1

Baseline of included patients according to treatment group.

Characteristic	LP group (n = 18)	BCFS group (n = 14)	*P* value
Age (mean ± SD, range, years)	79.3 + 11.4, 67-85	77.5 + 9.6, 65-86	.63
Gender, male/female	4/14	3/11	.96
Smoking (n, %)	5 (27.78%)	2 (14.29%)	.37
Fracture displacement (mean ± SD, cm)	2.82 ± 0.52	2.74 ± 0.36	.61
Fracture shortening (mean ± SD, cm)	1.85 ± 0.72	1.91 ± 0.85	.83
Time to surgery (mean ± SD, range, d)	4.04 ± 2.20, 2-7	3.85 ± 2.18, 3-8	.81
Follow-up (mean ± SD, range, months)	25.85 ± 11.69, 13-46	30.18 ± 9.65, 13-50	.25

Table 2

Operation related characteristics of included patients according to treatment group.

Groups	Cases (n)	Length of incision (mean + SD, cm)	Time of operation (mean + SD, min)	Intraoperatve blood loss (Mean + SD, mL)	Postoperative drainage (mean + SD, mL)	Postoperative hospital stay (mean + SD, d)	Fracture healing time (mean + SD, week)	Complication (n, %)
BCFS group	14	12.43 ± 1.22	77.50 ± 6.72	184.29 ± 42.56	58.57 ± 11.17	8.31 ± 1.20	14.93 ± 1.33	0 (0)
Plate group	18	16.33 ± 1.75	95.56 ± 11.10	263.33 ± 45.11	100.00 ± 12.83	12.33 ± 1.71	18.56 ± 7.25	2 (11.1)
T value		7.42	5.69	5.08	9.75	7.80	2.08	0.93
P value		<.001	<.001	<.001	<.001	<.001	.04	.350

Table 3

Outcomes of VAS scale for pain, rate of satisfied patients according to treatment groups.

Outcome measurement	Plate group (N = 18)	BCFS group (N = 14)	OR/MD (95% CI)	*P* value
VAS scale (mean + SD)				
First day	5.87 + 2.11	5.36 + 1.37	0.51 (-0.70-1.72)	.41
First week	2.55 + 1.38	2.32 + 1.45	0.23 (-0.76-1.22)	.65
First month	0.95 + 0.58	0.77 + 0.62	0.18 (-0.24-0.60)	.40
Third month	0.55 + 0.28	0.35 + 0.26	0.20 (0.0-0.39)	<.04
Patient satisfaction (n, %)				
First month	14 (77.78%)	12 (85.71%)	0.58 (0.09-3.76)	.57
Third month	16 (88.89%)	13 (92.86%)	0.62 (0.05-7.57)	.70
Sixth month	16 (88.89%)	13 (92.86%)	0.62 (0.05-7.57)	.70
Twelfth month	17 (94.44%)	13 (92.86%)	1.31 (0.07-22.93)	.85

Table 4

Outcomes of complications according to treatment groups.

Outcome measurement	Plate group (n = 18)	BCFS group (n = 14)
Major complications (n)		
Delayed union	2	0
Nonunion	0	0
Deep infection	0	0
Total implant failure	0	0
Reoperation	0	0
Minor complications (n)		
Hematoma	1	0
Hip/knee pain	1	1
Implant-related pain	2	1

Table 5

Outcomes of limb function according to treatment groups.

Groups	Cases (n)	Excellent (n, %)	Good (n, %)	Medium (n, %)	Bad (n, %)	Rate of excellent and good (n, %)
BCFS group	14	8 (57.1)	4 (28.6)	2 (14.4)	0 (0.0)	12 (85.7)
LP group	18	9 (50.0)	6 (33.3)	3 (16.7)	0 (0.0)	14 (83.3)

Comparison of excellent and good rates according to the treatment groups: $\chi^2 = 0.162$, *P* value = .722.

- Type A: proximal fracture of the intramedullary nail.
- Type B: intramedullary nail body or tip fracture.
- Type C: distal intramedullary nail fracture.
- Type D: fracture of femoral head and neck around intramedullary nail.

According to the classification, it is possible to select the corresponding treatment. The hip stem prosthesis periprosthetic Vancouver B1 fracture is stable. In particular, the periprosthetic fracture of the biologically fixated femoral components half a year after the operation is very similar to the Vancouver B fracture of postoperative intramedullary nail fixation of intertrochanteric fracture of the femur. It is usually caused by torsional stress in daily life and is the most common type. The standard treatment is open reduction and internal fixation. This study aims to analyze the efficacy of two different treatment modalities, BCFS and LP, for these two types of fractures.

Elderly patients have different degrees of osteoporosis during treatment and, at the same time, have less tolerance to anesthesia and surgical trauma. Therefore, higher requirements are required for convenient operation, minimal invasiveness, and reliable fixation in the treatment of the fixation method. The periprosthetic femoral Vancouver B1 fracture is a stable fracture with good bone quality. If the prosthesis is renovated, it will cause great trauma. At the same time, an additional handle is required, which is expensive and is not recommended clinically. When the intramedullary nail fixation periprosthetic refracture occurs, the original fracture has healed, with no need to consider intramedullary nail loosening because it does not affect the choice of the later treatment plan. Therefore, patients with type B fractures do not need to be subdivided into subtypes based on nail loosening. If the lengthened PFNA is replaced, the original implants should be removed. Surgical trauma and bleeding are more likely to be complicated by wound infection. At the same time, there may be a risk of loose fixation caused by a loose reamer. If the fracture is complex, the continuity of the cortical bone is difficult to guarantee, which is not commonly used in clinical practice. Therefore, the main challenge in dealing with such fractures is to select the appropriate internal fixation to connect the fracture ends. LP does not require friction by the bone plate in contact with the surface of the bone, which reduces the osteonecrosis under the steel plate and the impact on the growth of new bone and bone reconstruction, and improving stability by the lock mechanism between the bone plate and the screw.[20] A single cortical screw can be inserted into the proximal end of the fracture because it does not require special treatment of the original implant and reduces surgical trauma. However, there are also some problems. For example, the position of the screw is constant, the direction of nail placement is single and restricted, and only a single cortical screw can be placed at the proximal end, making the fixation imprecise due to the limitation of the number of nail holes.

The BCFS has become a multiple scaffold complex by integrating the advantages of the existing screw plate system, intramedullary nail system, external fixation scaffold, biological effects, biomechanical characteristics, and surgical performance to achieve a personalized internal fixation concept. Zahn et al[21] used animal experiments and biomechanical tests to show that the BCFS has certain advantages in treating complex fractures. In addition to the advantages of LP, it also has the following advantages when it is applied to fix the hip stem prosthesis or intramedullary nail periprosthetic refracture:

1) Compared with LPs, the BCFS has a smaller contact area of the fully-locked stent structure. At the same time, the fixed module crosses the fracture line, avoiding or reducing the electrolytic rejection reaction. In addition, it has a better blood supply and protective function, promotes fracture healing, and increases nutrition at the fracture end, improving the local anti-infection ability. No postoperative infection occurred in all patients in this study.
2) BCFS is easy to apply, the combined fixing block can slide freely without clinging to the leather, and the connecting rod is easy to shape and can be shaped in multiple directions. It has functions such as automatic fitting, stretching, compression, and rotation regulation, which can assist in fracture reduction, facilitating fracture reduction.[22] In this study, the operative time of the BCFS group was significantly shorter than in the LP group, reducing the incidence of limb shortening and providing a basis for good functional recovery.
3) "Bridging fixation" and "elastic fixation" with multilevel and locking saltatory implanted screws increase the number and flexibility of implanted screws' position. In addition, they make the stress distribution uniform, relieve stress concentration, effectively avoid stress shielding, and reduce the risk of internal fixation fracture and refractures at the distal and proximal ends of internal fixation.[23] There was no case of re fracture and failure of internal fixation in this group.
4) BCFS can be freely combined with multiple connecting rods and modules and fixed in multiple directions. On the one hand, compared with the eccentric fixation of plate osteosynthesis, the formation of the spatial formula "three-dimensional fixation" and the proximal end of the fracture is expected to achieve double cortical fixation. On the other hand, BCFS fixation is more reliable, improves the pull-out strength, and provides a reliable guarantee for early functional exercise. In this study, lower limb exercise was instituted 48 hours after surgery, and no loosening occurred. On the other hand, it could effectively prevent the screws from penetrating the adjacent joint cavity, reducing the requirements of the nailing technique, creating a flexible application space for the operator, and improving the safety of the operation.[24]
5) The hook-type link block can arbitrarily fix a large fracture block, which is conducive to restoring the integrity of the fracture and promoting the healing of the fracture.
6) The connecting rod and the module can be combined freely without restricting the length, which reduces the possibility of re-fracture due to the limitation of the length of the steel plate and is more suitable for ultra-long comminuted fractures.
7) The connecting rod can be placed under the skin, and only the implanted screws' position is cut, and the connecting rod is inserted during the operation, which significantly shortens the length of the surgical incision and reduces intraoperative bleeding, consistent with the results of this study.
8) The slight axial sliding can implement "dynamic compressing" to promote fracture healing.

This study compared the clinical differences between BCFS and LP in the treatment of postoperative implant periprosthetic refracture of geriatric proximal femoral fractures. The results showed no significant difference in postoperative fracture reduction, fixation, and limb function recovery in the LP group. During the follow-up period, no internal fixation fracture, nonunion, or re-fracture occurred in the two groups, and good results were achieved. However, the BCFS can shorten the length of the surgical incision, and the operative time, the postoperative hospitalization time. It also shortens the fracture healing time, reduces intraoperative bleeding and postoperative drainage volume, and dramatically reduces secondary trauma caused by surgery.

This study had several limitations. Firstly, our study was a single-center retrospective observational controlled study, and the cases were not from the same surgeon. Due to these reasons and single-center confounding factors, the level of evidence was lower than that of a randomized controlled trial. Secondly, the number of included cases was small; although the power test yielded the minimum inclusion criteria of 0.8 for the trial, the stability of the results decreased. Thirdly, the follow-up time of some patients was short, which could not rule out the possibility of refracture due to stress concentration around the implant in the future. Fourthly, BCFS, as a new technology whose stability depends on the rod-block connection and rod stiffness, should be further evaluated. Postoperative link slip might occur, which was also characteristic of BCFS failure. Long-term effects and complications still need further observation.

5. Conclusion

In summary, considering the benefits of multi-directional screw implantation, BCFS can effectively fix the fracture while reducing the loss of the femoral stem, protecting the local blood circulation, reducing trauma, and promoting early functional recovery in treating proximal femoral prosthesis refracture. Therefore, BCFS can be used as an alternative treatment modality for proximal femoral periprosthetic fractures in addition to locking plates, providing a new treatment idea for clinicians.

Acknowledgments

NA.

Author contributions

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