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CASE REPORT

Modified fixation for periprosthetic supracondylar femur fractures: Two case reports and review of the literature

Qin-Wen Li, Bin Wu, Bo Chen

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Abstract

BACKGROUND

Periprosthetic supracondylar femoral fractures (PSFs) present a challenge in terms of optimizing fixation in patients with poor bone quality. Surgical treatment and peri-operative management of PSFs in the elderly remain a burden for orthopedic surgeons. Among different treatment options, locking plate (LP) and retrograde intramedullary nail (RIMN) have shown favorable results. However, reduced mobility and protected weight-bearing are often present in the postoperative older population. With a purpose of allowing for early weight-bearing, a modified nail plate combination (NPC) was redesigned for PSF management.

CASE SUMMARY

In our cases, two elderly osteoporotic female underwent total knee arthroplasty (TKA), and then suffered from low energy trauma onto their knees after falling to the floor. Plain radiographs or computed tomography scans demonstrated oblique or transverse PSFs, both of which occurred at the distal femur above TKA. The modified NPC technique was performed for treatment of PSFs. The patient was made foot flat weight bearing in 1 wk. At 6-mo follow-up, the union was ultimately achieved using modified NPC with satisfactory implant outcomes.

CONCLUSION

Neither LP nor RIMN alone may provide adequate support to allow for union in circumstances where the patient has severely osteopenic bone. Therefore, developing a modified implant offer an alternative choice for treating PSFs. These two cases revealed that this technique is a viable option for the geriatric osteoporotic PSFs, offering safe, early weight bearing and favorable clinical outcomes.

Key Words: Periprosthetic supracondylar femoral fracture; Modified nail plate combination; Elderly osteoporotic patient; Early weight bearing; Case report

Core Tip: In this article, we reported two cases of elderly osteoporotic patients with periprosthetic supracondylar femoral fractures (PSFs) in the setting of total knee arthroplasty (TKA) after treated with modified nail plate combination (NPC), which was granted by the Trademark Office of China National Intellectual Property Administration. Unlike inserting retrograde intramedullary nail (RIMN) for holding the reduction after the initial reduction of fragments in previous NPC cases, it is the modified locking plate (LP) that performs the initial reduction and fixation of the distal femoral fragments in our cases. Initial reduction and fixation with LP and then insertion of RIMN can avoid an extension deformity in nailing of PSFs due to the femoral component of the TKA occluding the optimal start point. In patients with osteoporosis, modified NPC is beneficial and effective, attributed to early weight bearing and favorable clinical outcomes.

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INTRODUCTION

The rate of periprosthetic supracondylar femoral fractures (PSFs) above total knee arthroplasty (TKA) ranges between 0.3% and 2.5% in the literature, and higher after revision TKA[1]. The imminent raise of PSFs is associated with the increased life expectancy of the population as well as the steadily increased number of TKAs in the future[2]. The majority of these PSFs can be attributed to low-energy trauma including ground-level falls, and other common risk factors, including the aging, the female and other pathological conditions, such as osteoporosis, rheumatoid arthritis, chronic use of steroids, neurologic disorders along with revision TKA, making patients predisposed to periprosthetic fractures[3,4]. PSFs pose a management challenge by the prosthesis's stability and type, the available bone's quality and quantity for fracture fixation in the distal femoral metaphyseal region, the displacement's fracture pattern and degree as well as the surgeons' clinical experience[5]. Achieving stable fixation to allow early mobility is the goal of their treatment. Among different treatment options, the exclusive application of a laterally locking plate (LP)/an retrograde intramedullary nail (RIMN) usually warrants a 4-6 wk period of protected weight-bearing rather than early weight bearing as tolerated, especially in those with osteoporosis[6]. Combining the 2 implants could make the construct well balanced and adequate fixated, allowing for early weight bearing after surgery. Herein, we reported two cases of elderly osteoporotic patients with PSFs in the setting of TKA which went on to union after treated with modified nail plate combination (NPC) technique.

CASE PRESENTATION

Chief complaints

Case 1: A 71-year-old Chinese female was presented to our institution, complaining of the pain, swelling, and limitation of motion in right knee because of falling to the floor.

Case 2: Another 73-year-old Chinese female was presented to our institution with pain, swelling, and limitation of motion in the left knee because of slipping and falling from standing position.

History of present illness

Case 1: The patient suffered from pain, swelling, and limited movements of her right knee due to an accidental fall. She was taken to our institution quickly for radiograph examination.

Case 2: The patient went through an accidental fall to the left knee. She came to our institution for better treatment and nursing and given radiograph and computed tomography (CT) scan.

History of past illness

Case 1: The patient's pertinent surgical history of a right TKA 1 mo earlier was pivotal for her PSF.

Case 2: Her left TKA was applied 2 years before presentation.

Personal and family history

Case 1: The patient denied any traumatic history associated with PSFs in his family.

Case 2: Her family also had no significant trauma history of PSFs.

Physical examination

Case 1: Physical examination on admission revealed slight swelling of the right thigh and knee, local tenderness and percussion pain, and limited movement of the right knee.

Case 2: On admission, the results of the physical examination were consistent with Case 1.

Laboratory examinations

Case 1: After admission, the bone mineral density (BMD) examination showed that her BMD values were 71% and 68% of the young adult mean (YAM) at the lumbar spine and femoral neck, respectively. Other routine examination indexes were basically normal.

Case 2: Her BMD values were 62% and 65% of the YAM at the lumbar spine and femoral neck, respectively. Other laboratory examinations before surgery were also basically normal.

Imaging examinations

Case 1: Plain radiographs revealed a right PSF above the TKA femoral component, which was non-comminuted and oblique (Figure 1).

Case 2: Based on the results of radiographs and CT scans, a left PSF just above the anterior flange of femoral prosthesis was found, which was non-comminuted and transverse (Figure 2).

FINAL DIAGNOSIS

Cases 1 and 2: The patients were diagnosed as periprosthetic supracondylar femoral fractures and osteopetrosis.

TREATMENT

Cases 1: For surgery, modified NPC technique was applied in PSF situation, consisted by a specially designed periprosthetic LP, a RIMN and an intramedullary targeting arm, granted by the Trademark Office of China National Intellectual Property Administration (Patent for the invention No. ZL 2017 2 1268551.1 from September 29, 2017). As shown in Figure 3, the 2 distal locking holes of the specially designed periprosthetic LP were perfectly matched with the 2 distal interlocking holes of the RIMN in terms of spacing and angle. More importantly, the modified LP had a staggered pattern for insertions of other locking screws and K wires to avoid the nail and distal TKA implant. In operation, a limited lateral parapatellar approach facilitated enough exposure for proper assessment and fixation. Provisional reduction of the femur was successfully performed using reduction clamps. A modified LP was placed. Next, K wires were inserted to the distal end of femur to pin the plate in the appropriate site, while unicortical or bicortical screws were inserted to fix the proximal femur. Subsequently, a RIMN was transtendinously inserted. Usually, the targeting arm could help to choose the correct 2 distal locking holes of modified LP. With the application of 2 distal locking screws for the plate, the linkage was further reinforced based on the locking mechanism with a fixed angle. Then, 2 or 3 extra locking screws were filled at the distal end of LP. Finally, the proximal interlocking screw was placed in the RIMN, fixing proximal side of the construct (Figure 4A). Data on operative variables were obtained from medical record. Surgical duration totaling 126 min was recorded, while a hospital stay of 12 d was also observed.

Case 2: Similar surgical procedures were carried out as described in case 1 (Figure 5A). Operative time was 135 min totally, and the hospital length of stay was 14 d.

OUTCOME AND FOLLOW-UP

Cases 1: The patient followed a protocol of active-assisted knee range of motion and quadriceps strengthening from day 1 and foot flat weight bearing in 1 wk. Finally, bone union in six months was observed in her follow-ups (Figure 4B).

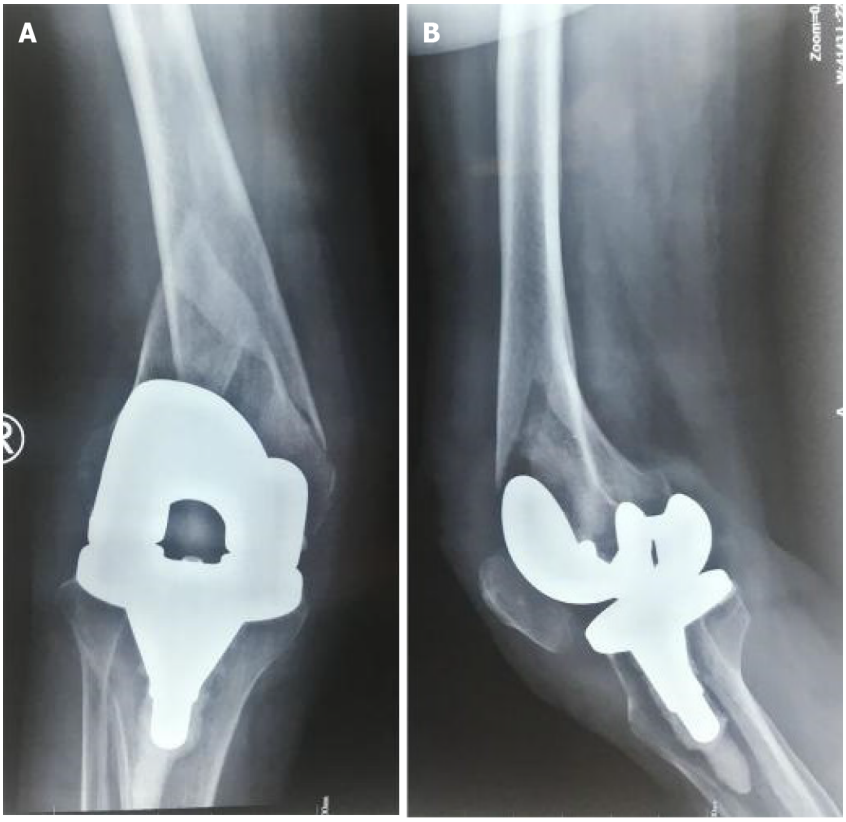

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Figure 1 Preoperative images of case 1. A: Anteroposterior radiographs of the right distal femur at the time of presentation showing the supracondylar femoral fracture above total knee arthroplasty which was non-comminuted and oblique; B: Lateral radiograph of the right periprosthetic supracondylar femoral fracture.

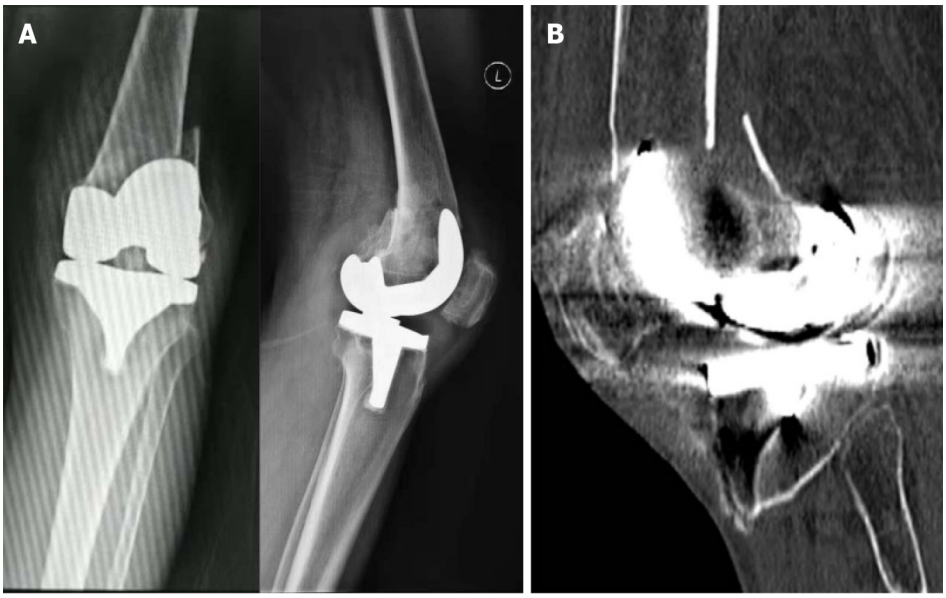

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Figure 2 Preoperative images of case 2. A: Plain radiographs of the left distal femur at the time of presentation showing the supracondylar femoral fracture just above total knee arthroplasty, which was non-comminuted and transverse; B: Sagittal computed tomography image of the left periprosthetic supracondylar femoral fracture.

Case 2: Similar post-operative rehabilitation protocols were carried out as described in case 1. Six months after the operation, the patient was able to walk unaided and without any pain. Her PSF was healed (Figure 5B).

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Figure 3 Implant of modified nail plate combination. Image of implant showing a specially designed periprosthetic locking plate, a retrograde intramedullary nail, an intramedullary targeting arm, locking screw guide and k wires.

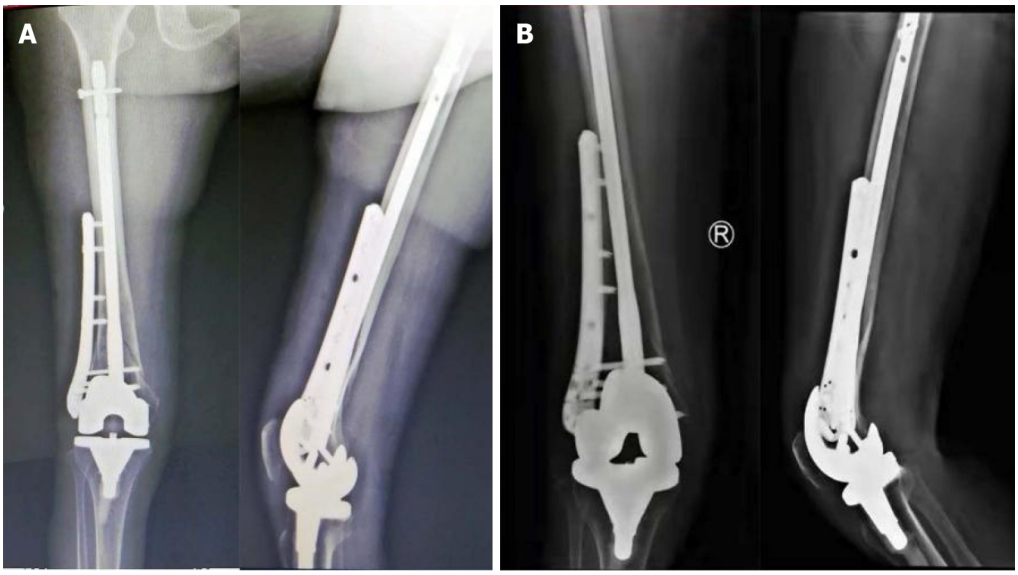

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Figure 4 Postoperative and follow-up images of case 1. A: Anteroposterior and lateral X-ray showing good reduction of periprosthetic supracondylar femoral fracture through modified nail plate combination; B: Anteroposterior and lateral X-ray taken 6 mo later showing evidence of union.

DISCUSSION

PSFs are frequently observed in fragility fractures accompanied by osteoporotic bone quality, very demanding complications of TKA. In the metaphyseal region of the distal femur with an obvious long segment of thin cortex as well as a soft metaphysis, a simple twisting injury can cause a fracture propagating almost the entire distal third of the femur. Biomechanical studies have also revealed that the supracondylar bone proximal to a TKA implant was weaker due to stress shielding and osteolysis [7]. The occurrence of a TKA is linked with a bone loss of about 15% in the distal diaphyseal and metaphyseal region near the prosthesis[8].This bone loss in combination with the increased prevalence of osteopenia could obviously upregulate the risk for periprosthetic fractures. The great mass happened in female and the injury caused by "slip fall" is the most common[9].Reduced mobility along with

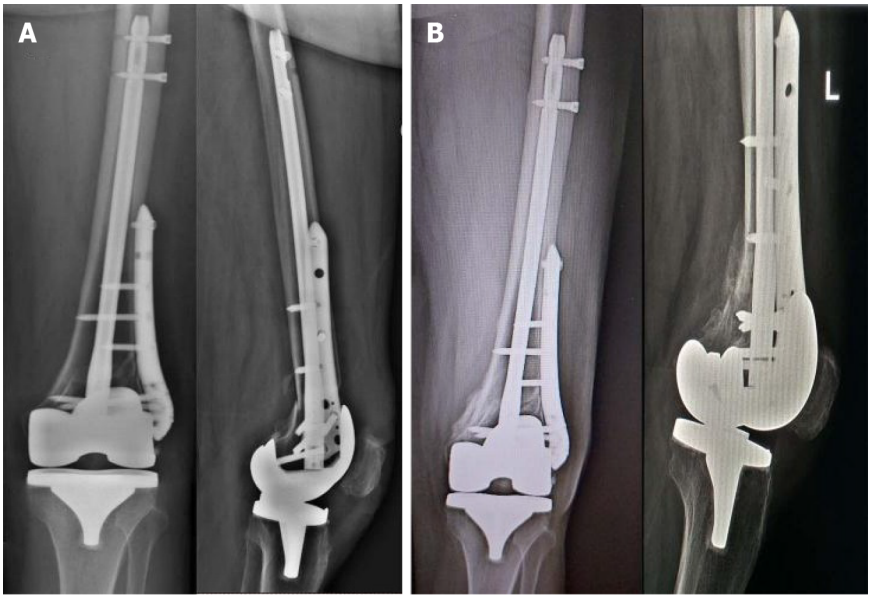

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Figure 5 Postoperative and follow-up images of case 2. A: Anteroposterior and lateral X-ray showing good reduction of periprosthetic supracondylar femoral fracture through modified nail plate combination; B: Anteroposterior and lateral X-ray taken 6 mo later showing evidence of union.

general osteoporosis attributed to age or sex can be found in the elderly. In our cases, both of 2 osteoporotic patients were female and elderly that suffering from PSFs due to low energy trauma.

The management of PSFs remains challenging. A number of complications, such as the delayed union, nonunion, stiffness and infection have been ever observed during PSF treatments. Recently, a systematic analysis reported a non-union rate of PSFs to be 10%-15%, irrespectively of the treatment method[10]. Therefore, to decrease complication and reoperation rates, there have been various treatments for PSFs performed, including newer fixatives to maintain fracture reduction and additional strategies reported for unreconstructable fractures. Besides, it is well recognized that in most of the cases, operative intervention is in urgent need for these complex fractures, however, a gold standard for surgical fixation remains unclear. According to the literature, compared to extensive approaches and rigid anatomic fixation methods, the treatment of PSFs after TKA is evolving toward minimally invasive percutaneous plate osteosynthesis and RIMN[11]. The modern LP and RIMN technology have been demonstrated to be superior in biomechanical and clinical outcomes in contrast with conventional non-locked plating[12]. Due to the similarity in application period and fracture healing biomechanism between LP and RIMN, numerous comparative studies have been carried out[13]. Despite of their specific merits as well as the different indications attributing from their unique fixation mechanism, recent systematic reviews and meta-analysis consistently demonstrated no statistically significant differences in clinical results, time to fracture union, complication rate, or the range of postoperative motion between the two treatment options (Table 1)[14,15]. LP can be applied in most PSF types and prosthesis designs and allows for of direct reduction except for medial femoral cortical defects[10,16]. Moreover, a polyaxial LP allows a reduction of distal small fragments in direction to the plate, accompanied by sufficient relative stability for fracture healing[17]. However, for elderly osteoporotic populations, surgeons are cautious about early weight bearing with a LP fixation. LP can also be inserted submuscularly through a minimally invasive approach with minimum disruption of the fracture healing microenvironments. However, it also inevitably dissect a certain amount of soft tissue with the potential of periosteal stripping. Comparatively, RIMN was also identified as a minimally invasive and soft-tissue-friendly internal fixation method as reported in orthopaedic literature for treating PSFs[18]. The fact that RIMN is coaxially implanted along the anatomical axis of the femur endowing this implant the stiffest construct under axial loading due to an short moment arm from the axis of applied load to the neutral axis of the nail[19]. Notably, the exclusive application of RIMN relies on fracture pattern as well as intercondylar box design of femoral components. The distal fixation is possibly not adequate for very low supracondylar fractures[20]. Malunion of typically extension deformities has been frequently reported in the setting of RIMN since the entry point of the RIMN is set based on the femoral component box, which forces the fracture into hyperextension, and make the reliance on indirect reduction with RIMN techniques[21]. The inevitably mismatched diameter of the nail with metaphyseal flare may make the nail toggled in the metaphysis, posing a risk to the fixating stability in osteoporotic patients[22]. Restricting postoperative mobilization can be a problem in the elderly osteoporotic patients based on the fact that early weight bearing and returning to baseline activity are able to directly reduce the morbidity and mortality of patients. Therefore, NPC is developed

Table 1 Comparative outcome data between locking plate and retrograde intramedullary nail groups

	LP	RIMN	*P* value
Six month union rate	87.5%	83.5%	0.68
Union time	4.0 ± 0.27 mo	3.7 ± 0.30 mo	0.95
Operation time	87.4 ± 6.4 min	91.6 ± 6.8 min	0.46
Complication rate	20.6%	16.7%	0.73
Postoperative knee functional score	76.5 ± 14.5	80.6 ± 10.9	0.31

LP: Locking plate; RIMN: Retrograde intramedullary nail.

as a novel method for fracture fixation which has been applied in several years, with the aim of providing stable fracture fixation and allowing for early postoperative weight bearing[23].

As previously reported, augmented fixation with NPC has been conducted in patients who failed from the fixation of single plate or nail and required surgeries for nonunion and revision, or when a proximal hip replacement stem needed to be bridged[24,25]. Currently, it has been increasingly applied in PSFs primary fixation. Over the past several years, there were relatively few cases using NPC for the treatment of PSFs after TKA, however, the union rate was approximately 100% at their follow-ups[23,26-28]. There have also been few comparative studies between NPC and traditional fixations performed previously. Compared to LP alone, fixation with NPC significantly improve fracture union rates in elderly patients[29,30]. Biomechanically, compared to LP or RIMN, NPC was more resistant to the failure in axial and torsional load tests as well as the load to failure tests[31,32]. According to their biomechanical experiments, higher mechanical strength of the combined construct and the possibility of earlier mobilization make it an advantageous option in patients with osteoporosis. An advantage of the NPC over dual plating is that there is less disturbance of the fracture milieu[29]. Furthermore, linking the LP and RIMN distally potentially achieve more evenly distribution of forces contributing to the stability and early weight bearing[27].In our cases, we presented a modified NPC technique, which involves a specially designed periprosthetic LP for adequate fixation of the fracture. Unlike inserting RIMN for holding the reduction following the initial reduction of fragments in previous NPC cases, the modified LP that performs the initial reduction and fixation of the distal femoral fragments in our cases. Insertion of RIMN then allows for further stable fixation of the distal construct and increasing torsional stiffness, further avoiding the extension deformity in nailing of PSFs due to the femoral component of the TKA occluding the optimal start point. Regarding of distal fixation, 2 bicortical interlocking screws were placed to link the plate and the nail. Based on available literature on distal screws, 2 distal interlocking screws in the nail are recommended in the setting of severely osteoporosis or those in need of the increased resistance to torque[28]. Furthermore, PSF patients should also bear the increased cost of supplemental implants for the potential early weight-bearing.

CONCLUSION

We reported two cases of periprosthetic supracondylar knee fractures treated with modified NPC technique in elderly osteoporotic patients. Since exclusive LP or RIMN is in need of protected weight bearing, NPC is much more preferable for elderly osteoporotic populations allowing for postoperative earlier mobilization and shared load bearing across the fracture site. In the two cases, the distal femoral fixation was achieved through the modified NPC technique with the reduction using a specially designed periprosthetic LP, which can avoid the extension deformity in the later healing period owing to more posterior starting point of RIMN. Future studies need to be directed toward larger populations of patients along with cost analysis for the increased costs for the implants.

FOOTNOTES

Author contributions: Li QW involved in patient care, conducted literature analysis and wrote the manuscript; Wu B collected the clinical data and analyzed the results; Chen B performed the operation and revised the manuscript; All Authors approved the final version.

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