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Plate-on-plate technique for treating peri-implant fractures of distal femoral locking plate: a retrospective study of 11 patients

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Abstract

Introduction In this study, we aimed to ascertain the feasibility and reliability of the plate-on-plate technique for peri-implant fractures of the distal femoral locking plate when the distal femoral fracture is still unhealed.

Materials and methods From January 2007 to December 2016, we enrolled 11 patients who received treatment at our institution. All patients underwent at least 1 year of follow-up. Their medical records, imaging studies, visual analogue scores, walking ability, complications, and functional outcomes at 1 year postoperative based on the Short Form (36) Health Survey (SF-36) scores were retrospectively evaluated.

Results The average follow-up duration was 20.5 (range 15–30) months. All fractures united with satisfactory alignment, and the average time for union was 27.5 (range 16–40) weeks. The average SF-36 scores at 1 year postoperative was 79.2 (range 72–90). Regarding ambulatory status, all patients could perform unrestricted outdoor ambulation.

Conclusion In our case series, the plate-on-plate technique achieved a good bone union rate and functional outcomes with low complication rates and thus may be a good alternative for managing this difficult type of fracture.

Keywords Distal femoral fracture · Peri-implant fractures · Complication of locking plate · Plate on plate technique

Introduction

Distal femur fractures account for 1% of all fractures and 3–6% of femur fractures [1, 2]. They are associated with high energy trauma (in young people) or osteoporotic bones (in the elderly) and are frequently comminuted and intra-articular [2]. The current treatment trend is toward operation with peri-articular distal femoral locking plates, which are pre-contoured plates with low profile and a fixed angle construct [3–7]. The pull-out strength of locking screws is higher than the conventional screws and is particularly useful in comminuted fractures and osteoporotic bones. However, locking plate-related complications, including non-union, delayed union, and implant failure, occur frequently and are ongoing problems in managing these fractures [4, 7–10].

In the past years, we have encountered patients with peri-implant fractures through the outermost proximal screw of the distal femoral locking plate, with or without healing of the original distal femur, making such fractures an increasingly and challenging problem for orthopaedic surgeons [11]. Chan et al. had ever introduced a classification system and management strategies for peri-implant fractures of distal femoral plate [12]. However, there is no consensus regarding the optimal treatment for peri-implant fractures of distal femoral locking plate when the original fracture is still unhealed. This retrospective study aimed to investigate the feasibility and reliability of using a plate-on-plate technique for treating these difficult cases.

Patients and methods

From January 2008 to December 2016, 437 patients with 440 distal femoral fractures were treated with a distal femur locking plate at our institution. Of these, 28 (6.8%)

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developed a peri-implant fracture at the outermost proximal locking screw. Meanwhile, 11 (2.5%) patients with unhealed distal femoral fracture who were treated with the plate-on-plate technique were enrolled in our study (Table 1). After institutional review board approval was obtained, patients' medical records were reviewed retrospectively.

The patients' average age was 66.5 (ranging from 22 to 86) years. There were seven female and four male patients. A Less Invasive Stabilization System (LISS-DF; Synthes, Paoli, PA, USA) was used in six cases and a ZPLP-DF (Zimmer, Warsaw, India, USA) was used in five cases for original distal femoral fracture. The average time from osteosynthesis of distal femur to the peri-osteosynthesis femur fracture was 12.4 weeks in average (ranging from 3 to 23 weeks). Four peri-implant fractures occurred in the subtrochanteric area of the femur and seven in the proximal femoral shaft. Both fractures of the femur were classified according to AO/OTA [13].

Radiographic follow-up examinations were performed at each visit after surgery until fracture site union was evident. The clinical outcomes were assessed by asking the patients to evaluate their pain based on a visual analogue scale (VAS), using a scale of 0–10 (0, no pain and 10, the greatest pain possible) [14]. Complications such as change in fracture alignment, hardware failure, and infection were recorded. Bone healing was considered if patients tolerated weight load with no pain and X-rays showed bone bridges in the fracture site. Delayed union was defined as healing that extended beyond 6 months from the time of surgery. Non-union was defined as the absence of progressive signs of healing for 3 months after 6 months have elapsed from the date of the surgery. Malunion was defined as 5° of deformity at the fracture site on either of the anteroposterior or lateral views. The functional outcomes were measured using the Short Form (36) Health Survey (SF-36) at 1 year postoperative [15]. The walking ability was also evaluated at 1 year postoperative, and was classified as follows: sedentary (class 0); indoor ambulation only (class 1); restricted outdoor ambulation (class 2); unrestricted outdoor ambulation, light work (class 3); and unrestricted outdoor ambulation, heavy work (class 4) [16].

Management protocol

Medical record and X-ray assessments were performed to identify the previous distal femoral locking plate system (a LISS-DF or ZPLP-DF) and the fracture pattern. Once associated injuries were ruled out and medical clearance was obtained, patients were taken to the operating room. All patients with unhealed distal femur fracture were treated with the plate-on-plate technique (Fig. 1). During the operation, patients were placed in a lateral decubitus position on a standard orthopaedic table. The fracture fixation protocol included a standard lateral approach, spanning femoral fixation between the hip and knee using tissue-preserving exposure and reduction technique, and confirmation with image intensification. According to the plate system, a Non-Contact Bridging-Periprosthetic Plate (NCB-PP Zimmer Inc., Winterthur, Switzerland) was used, or a distal femoral locking plate that was designed for treating distal femoral fractures (LISS-DF or ZPLP-DF) of the contralateral limb was used reversely (Fig. 2). An adequate plate was selected based on the femur length. The locking plate was placed on the proximal femur and surface of the distal locking plate with overlapping screw hole of plates. Bicortical locking screws were placed into the shaft through the overlapping

Table 1 Patients' demographic data

Case	Age/sex	Mechanism	Time to peri-implant fracture (weeks)	AO/OTA classification origin/peri-implant	Implant original/new
1	68/F	Low energy fall	22	33-C2/32-A2	LISS-distal femur/LISS-distal femur
2	82/F	Low energy fall	20	PPTKR/32-A3	LISS-distal femur/LISS-distal femur
3	77/F	Low energy fall	10	33-C2/32-B2	LISS-distal femur/LISS-distal femur
4	22/M	RTA-motocycle	8	33-C3/32-A1	ZPLP-distal femur/NCB-PPS proximal femur
5	41/M	RTA-motocycle	11	33-A3/32-A3	ZPLP-distal femur/ZPLP-distal femur
6	74/F	Low energy fall	15	PPTKR/32-A2	LISS-distal femur/LISS-distal femur
7	86/F	Low energy fall	6	33-C2/32-A1	ZPLP-distal femur/NCB-PPS proximal femur
8	65/M	Low energy fall	13	33-A1/32-A2	LISS-distal femur/NCB-PPS proximal femur
9	71/M	Low energy fall	5	33-C3/32-B2	LISS-distal femur/NCB-PPS proximal femur
10	66/F	RTA-motocycle	23	33-C2/32-A1	ZPLP-distal femur/NCB-PPS proximal femur
11	79/F	Low energy fall	3	PPTKR/32-A3	ZPLP-distal femur/NCB-PPS proximal femur

RTA road traffic accident, *PPTKR* peri-prosthetic fracture of total knee replacement, *LISS* less invasive stabilization system (synthes), *ZPLP* Zimmer periarticular locking plate system (Zimmer), *NCB-PPS* non-contact bridging periprosthetic plate system (Zimmer)

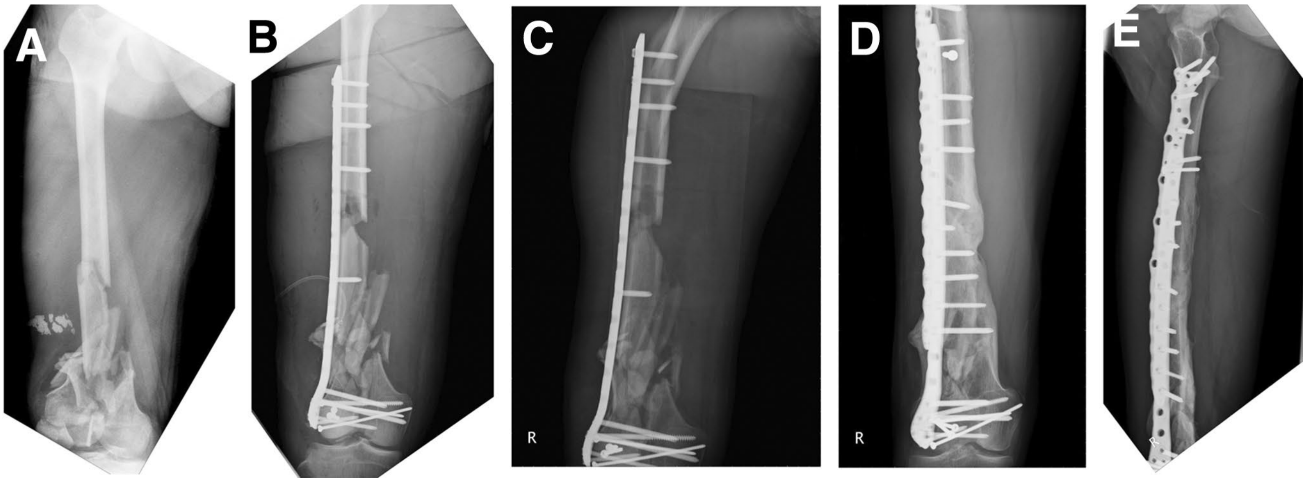

Fig. 1 **a** A 22-year-old male sustained a distal femoral comminuted fracture (AO/OTA 33-C3). **b** Locking plate fixation is performed using a minimally invasive technique. **c** At 8 weeks post-surgery, he had a peri-implant fracture (AO/OTA 32-A1) in the outermost screw hole of the locking plate and unhealed original distal femoral fracture. **d**, **e** Radiographs in AP and lateral views show fracture union in satisfactory alignment using the plate-on-plate technique

Fig. 2 Same or different locking plate system. Both locking plates can be placed up and down with the overlapping screw hole of the plates and act as two independent fixators to bridge both fracture sites

screw hole of two plates. A maximum number of locking screws were passed through the proximal metaphyseal segment of the fracture, and three screws were passed into the femoral shaft. Image intensification was used to guide placement of screws in the whole femur. Postoperatively, patients were allowed to sit up in bed on the day of surgery. Patients were kept heel-toe touch-down weight bearing in the immediate postoperative period. Once union was evident clinically and radiographically, gradual partial to full weight bearing as tolerated was then encouraged.

Results

The patients were followed up for a minimum period of 1 year with an average duration of 20.5 (range 15–30) months. All fractures united in satisfactory alignment (less than 5° of angulation at the fracture site), both clinically and radiographically (Table 2), and the average time for union was 27.5 (range 16–40) weeks. Healing was uneventful in ten patients (Fig. 3). Union was delayed in one subtrochanteric area fracture. Two patients reported pain in the medial aspect of the knee due to knee osteoarthritis. Two patients reported pain in the lateral aspect of the hip due to plate prominence (contralateral LISS-distal femur). In these cases, it did not restrict the patients' daily activities and could be controlled with oral pain killers. No patient developed infection. One patient had distal femoral non-union that required bone graft. The average SF-36 scores at 1 year postoperative was 79.2 (range 72–90). Regarding ambulatory status, all patients could perform unrestricted outdoor ambulation (class 3 or 4).

Table 2 Results

Case	Follow-up (months)	Union time (weeks)	VAS	SF-36	Ambulation status	Complication
1	30	28	1	83	3	Nil
2	28	40	2	74	3	Hip lateral aspect pain
3	24	38	4	72	3	Hip lateral aspect pain
4	18	24	0	90	4	Nil
5	16	16	0	88	4	Nil
6	24	20	2	80	3	Nil
7	18	32	5	76	3	Knee pain
8	15	24	2	82	4	Nil
9	20	20	4	76	3	Nil
10	18	28	3	76	3	Distal femoral nonunion
11	15	32	4	74	3	Knee pain

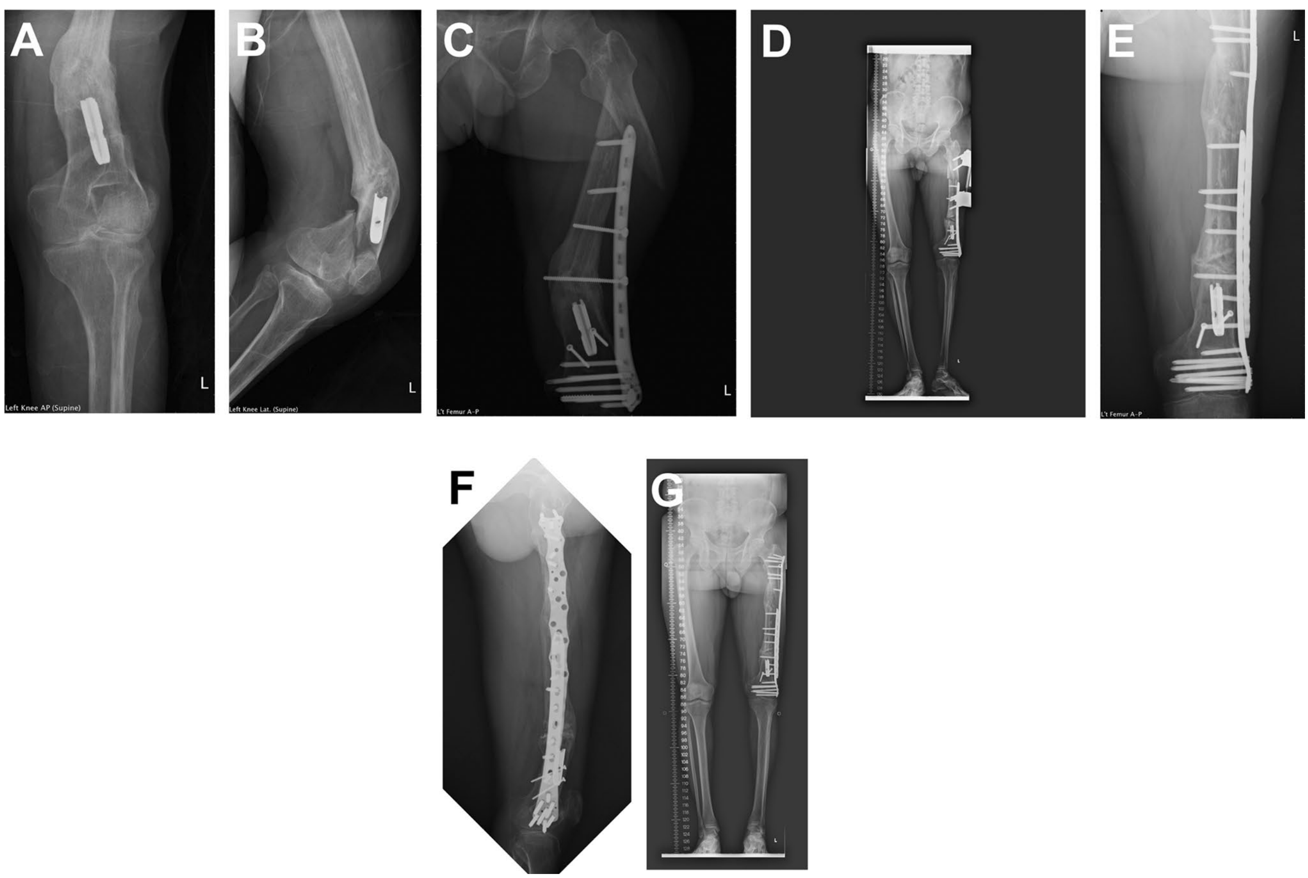

Fig. 3 **a**, **b** A 65-year-old male with femoral malunion and shortening of the left femur sustained a distal femoral fracture (AO/OTA 33-A1). **c** At 13 weeks after the locking plate fixation, he had a peri-implant fracture (AO/OTA 32-A2) and unhealed original distal femoral fracture. **d** He underwent corrective osteotomy and lengthening procedure. A distal femoral locking plate was used to stabilise the original distal femoral fracture and osteotomy site. **e**–**g** After the achievement of adequate femoral lengthening, bone grafting and plate-on-plate technique using a long proximal femoral locking plate were performed. Radiographs of AP, lateral view, and scanography show that the fractures had healed without any deformity and shortening

Discussion

Distal femoral fractures largely occur secondary to high-energy trauma in the younger population and as osteoporotic fractures in the elderly population, including periprosthetic fractures above TKA [2, 4]. Various treatment modalities, including external fixators, intramedullary nails, and plating systems, have been used for surgically managing distal femoral fractures [3–5, 17, 18]. Conventional plates, such as condylar buttress plates, condylar blade-plates, and dynamic condylar screws, have been previously extensively used, although they are currently disfavoured mainly because of their poor biomechanical properties [3–5]. Biomechanically, conventional plating is based on frictional forces between the bone and plate. Therefore, conventional osteosynthesis techniques might not be optimal for poor bone quality of metaphyseal, comminuted fractures, and periprosthetic fractures around TKR without sufficient bone stock. Furthermore, they lead to complications, especially infection, delayed union, and non-union [17–19].

Strong evidence to support the biomechanical advantages of the locking plate over traditional constructs is currently available [18, 20]. Locking plating systems, such as LISS and other polyaxial locking plates, provide more stable fixation because of better angular stability and pull-out resistance of locking screws, and they have been used for treating osteoporotic fractures, comminuted fractures, short segmental metaphysic fractures, and periprosthetic fractures around the distal femur [3–6, 21, 22]. Locking plates are less disturbing to the periosteal blood supply because bone compression is not required. Thus, they are ideal for bridging techniques in comminuted fractures and implementation of minimally invasive and indirect fracture reduction and fixation principles [3, 20]. Therefore, locked plating systems constitute the contemporary gold standard for fixation of distal femoral fractures.

Along with the increasing use of distal femoral locking plates, new and unique problems, including malunion, loss of fixation, and other implant-related shortcomings, have emerged [7–10]. Moreover, a peri-implant fracture of the distal femoral locking plate is becoming increasingly frequent, results in a serious treatment challenge for surgeon [11]. In the current study, the majority of cases were elderly patients with low velocity fall after distal femoral fracture fixation who had a simple transverse and short oblique fracture through the outermost screw hole. Mechanically, the end of the implant acted as a stress riser and predisposed the bone to further fractures [23]. Hence, a previous study recommended that conventional screw fixation should be done at the end of the locking plate to reduce the stress concentration at the plate end [24]. Sommer et al. report a 2.6% incidence rate of peri-implant fractures of the locking plate after a subsequent injury [25]. We also experienced 28 peri-implant fractures (6.8%) in our case series. The peri-implant fractures resulted from the stress concentration effect at the end of plate [26]. Difference in stiffness between the patient's bone and the plate-fixed bone segment can be another cause [27]. This difference in stiffness is particularly present in osteoporotic bone, where stress concentrations at the outermost screw hole increase the risk of peri-implant fracture [24].

Peri-implant fractures are uncommon and rarely reported in the literature. Moreover, there is still no consensus regarding its optimal treatment. There is also increasing difficulty in treating this type of fracture, especially if the original fracture remains unhealed. Factors contributing to our choice of stabilisation method included the incomplete union of the distal femur, continued stability of the distal femoral locking plate, and the location and geometry of the fracture. If the original distal femoral locking plate requires to be retained, this usually affects the subsequent placement of implants. Intramedullary nailing is recognised as the preferred treatment for unstable proximal and femoral shaft fractures and provides certain additional biomechanical advantages compared to fixation with a plate [19, 28]. Although using intramedullary nailing for peri-implant fractures is not impossible, it definitely increases the difficulty of performing the technique, as it requires the removal of the locking screws on the plate to allow reaming and nailing. Moreover, conventional or mono-cortex screws are used to fix the locking plate, and distal interlocking screws of the nail are difficult to insert owing to the obstruction caused by the plate. Additionally, it also appears to simultaneously reduce the stability of the locking plate and nail.

Long locking plates have been used for proximal femoral fractures and resulted in good clinical outcomes [4, 19, 29]. The challenge encountered by surgeons when using a locking plate to treat peri-implant fractures following the use of a distal femoral locking plate is how to properly place the second plate in a position that would result in non-interference between the implants, as well as provide adequate stability. In the current study, we introduced a simple solution (plate-on-plate technique) to this complex problem. This technique uses a long proximal femoral locking plate or reversed distal femoral locking plate to be placed on the proximal femur and the surface of the original distal locking plate. Despite the different locking plate system, both locking plates can be placed up and down with overlapping screw hole of the plates and can bridge the original distal femoral fracture and the new peri-implant fracture. Based on the biomechanical property of the locking plate, we recommend that the maximum number of locking screws should be passed through the metaphyseal segment and three bicortical locking screws should be passed into the femoral shaft. Both plates could act as two independent fixators; although the plate placed above is a little far from the bone surface, it still provides good stability [30–32]. Through this technique, it is only necessary to expose the lateral aspect of the femur to allow fracture reduction and plate placement without extensive soft tissue dissection. Hence, our plate-on-plate technique is easy to perform, has shorter operation time, lesser anaesthetic exposure, lesser soft tissue damage, and adequate fracture stability.

Two patients reported lateral hip pain caused by implant prominence; this was caused by necessary placement of the plate over the trochanteric area to fit the contour of reverse contralateral LISS-distal femur or ZPLP-distal femur plates. Hence, we recommend using an NCB-PPS proximal femur plate, which can be placed over the subtrochanteric area to decrease the possibility of implant irritation. Another concern in our case series is the possibility of galvanic corrosion, especially for patients in which different brands of implants come into contact with each other. Although the current literature has not shown increased corrosion between stainless steel and titanium [33, 34], we still recommend using implants of the same brand to prevent possible corrosion. Implant removal should be considered when bone solid union has been achieved.

Although the clinical outcomes in our case series are encouraging, there are some limitations to our study. First, only a small sample of patients were enrolled in this study. Second, this is a retrospective study, with the level of evidence being lower than prospective studies. Third, there was no control group for comparison. Further prospective randomised studies may be required to prove the feasibility and reliability of this technique for peri-implant fractures of distal femoral locking plate.

Conclusion

In conclusion, the plate-on-plate technique achieved a good bone union rate and functional outcome with low complication rates in our case series. Our technique enables a simple reduction of the fracture, placement of a new plate without extensive soft tissue dissection and implants interference, and provides an adequate fixation. Thus, it could be a good alternative method for managing these complex injuries.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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