의학석사 학위논문

원위 대퇴골 골절에서 이중 금속판 고정술의 결과 보고: 인공 슬관절 주변 골절과 인공 삽입물이 없는 골절의 비교.

Outcomes of dual plating for distal femur fractures: comparisons between periprosthetic versus non-periprosthetic fractures

울산대학교 대학원

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이 논문을 의학석사 학위 논문으로 제출함

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서재현의 의학석사 학위 논문을 인준함

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Abstract

Background: The aim of this study is to evaluate surgical outcomes of dual plating for the distal femur fractures with comparison between periprosthetic and non-periprosthetic fractures.

Method: This retrospective cohort study analyzed outcomes of dual locked plate fixation for distal femur fractures. 49 patients (43 females and 6 males) who were treated with double plate construct from July 2008 to August 2020 were included from institutionally approved orthopedic database. 29 patients were classified into periprosthetic fracture group (Group P), and the other 20 patients were designated to non-periprosthetic fracture group (Group N). Baseline data regarding age, sex, body mass index (BMI), injury mechanism and the fracture pattern including open injury, comminution, AO/OTA classification and Su classification were recorded. Radiographic outcome was evaluated with union time and mechanical lateral distal femoral angle (mLDFA). Clinical parameters included knee range of motion, walking ability using Koval score, and knee society score (KSS) at the postoperative 1 year. The need for reoperation and complications such as infection, mechanical failure, and non-union were also reviewed.

Results: Mean age at operation was 71.1 years, and the average follow-up period was 37 months (range, 12–138 months). Bony union was achieved in 47 patients (P 28, N 19) among total 49 patients (96%). Mean union time was 34 weeks in group P, 40 weeks in group N. The mean mLDFA after operation were restored to 90.5° (group P) and 87.7° (group N) and were maintained to 90.5° (group P) and 88.3° (group N) until final follow-up. Final knee range of motion arc angle on average were 130° in group P and 107° in group N. ($p = 0.14$) Final Koval score on average were 1.7 in group P and 1.8 in group N. Final KSS knee score on average were 73.8 in group P and 87.1 in group N. There was no case of infection, but 6 cases (12%) of secondary surgery: 1 case of nonunion, 2 cases of implant failure, 1 case of junctional fracture after slip down and 2 cases of implant removal due to symptomatic discomfort.

Conclusions: Dual plating for distal femur fractures showed excellent union rate and limb alignment with low complication rate. Overall outcomes were similar between periprosthetic and non-periprosthetic fracture groups. Dual plating on the distal femur would be a good surgical option for poor bone stock and comminution.

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Introduction

With an increase in aging population, incidence of total knee arthroplasty (TKA) and osteoporosis grows as the corresponding increase in periprosthetic and non-periprosthetic distal femur fractures.(1, 2) However, the optimal surgical treatment for distal femur fracture is still challenging due to several reasons such as poor bone quality, limited bone stocks, distal extension of fractures, medial cortical comminution, alteration in blood supply.(3-8) Previous single lateral locked plating for distal femur fractures showed their nonunion rate of up to 15%, which does not seem to be satisfactory outcomes in terms of fracture treatment.(9, 10) Typically in periprosthetic distal femur fractures (PPDFFs), Su type III fractures with distal fracture extension beyond anterior flange or cases with severely comminuted medial cortices were likely to fail with single lateral plating due to limited (poor) bone stock which led to insufficient fixation power and loss of medial buttress which led to varus collapse.(4, 5, 11) Additionally, several previous studies have shown that ORIF of non-periprosthetic distal femur fractures (NDFFs) with extensive metaphyseal comminution, particularly AO/OTA 33-C2 or 33-C3 type, results in high rates of mechanical complications such as varus collapse with medial comminution, loss of fixation and nonunion.(3, 12-15)

Dual plating for distal femur fracture has been introduced and explored to overcome these limitations for very distal periprosthetic femur fractures and AO/OTA 33-C2 or 33-C3 distal femur fractures.(4, 16, 17) And several radiological, cadaveric, biomechanical, clinical studies advocated promising results with safe and successful sub-vastus placement of additional medical plate without significant reduction of distal femur circulation.(16, 18-22) Recently, it was reported that in comminuted distal femur fractures or periprosthetic distal femur fractures, dual plating technique had excellent union rate and lower revision rate with better clinical outcome than single lateral locked plating technique.(16, 23) Another recent study showed that dual plate fixation had several advantages over nail-plate constructs with favorable outcome : feasibility to any arthroplasty component design, facilitation of coronal plane reduction, and allowance of immediate weight bearing.(17)

Despite the recent promising reports of dual plate fixation for distal femur fractures, there still is a paucity of literature on dual plating for distal femur fractures. The purpose of this study was to evaluate surgical outcomes of dual plating for the distal femur fractures with comparison between periprosthetic distal femur fractures (PPDFFs) and non-periprosthetic distal femur fractures (NDFFs). We retrospectively analyzed the radiographic and clinical outcomes of dual plate fixation and compared the outcomes between PPDFFs and NDFFs. We hypothesized that this technique would achieve satisfactory bone union rate and limb alignment with low complication rate and that periprosthetic and non-periprosthetic groups would show comparable outcomes with each other.

Methods

Study design & Patient selection

The single-centered retrospective cohort study was performed. The inclusion criteria were as follow: 1) distal femur fractures treated with dual plate, 2) age ≥ 20 years, and 3) follow-up ≥ 12 months from July 2008 to August 2020 were included from institutionally approved orthopedic database. We excluded patients with intra-operative periprosthetic fractures during TKA, previously known infection or obvious fracture related infection, severe polytrauma (ISS > 18), pathologic fractures, and radiation related fractures. To provide large sized empirical results of distal femur double plating, we enrolled suitable patients from our institutional database as much as possible. A total 49 patients (43 females and 6 males) were enrolled. And they were divided into two groups: 29 cases of the PPDFFs (group P) and 20 of NDFFs (group N).

Operation techniques and post-operative rehabilitation

Our indications of double plating were 1) when distal bone stock was severely limited due to far distally extended fracture such as Su type III PPDFFs, 2) far distal location of NDFFs, 3) medial wall comminution without medial buttress effect after reduction such as large butterfly fragments, and 4) poor bone quality of the elderly. Double plating consisted of medial and lateral plating with separate incisions. The order of fixation was largely dependent on fracture pattern and easiness of reduction. Fixation was tried to achieve through a limited open approach for fracture reduction and minimally invasive percutaneous osteosynthesis (MIPO) of the distal plate to preserve the local blood supply for the soft tissue and bone overlying the plate. Lateral MIPO using distal femur locking compression plate (Depuy Synthes®) and medial MIPO with subvastus approach using proximal humeral internal locking system plate (Philos, Depuy Synthes®) was the most frequent combination. Number of screws fixed in distal bone stock, working length and plate length were retrospectively recorded.

All patients followed the same standardized postoperative rehabilitation program and were encouraged to perform early assisted ambulation. Gentle passive knee range of motion (ROM) exercise using continuous passive motion machine was initiated after removal of drainage tube.

Patients were followed at six-week interval for the first three months and two-month interval thereafter until bone union was identified. At each visitation, we routinely obtained plain radiographs of the affected site using two orthogonal views: anteroposterior (AP) and lateral. Three-dimensional computed tomography (3D CT) was taken at postoperative 3 months and repeated when bone union seemed to be evident on radiographs.

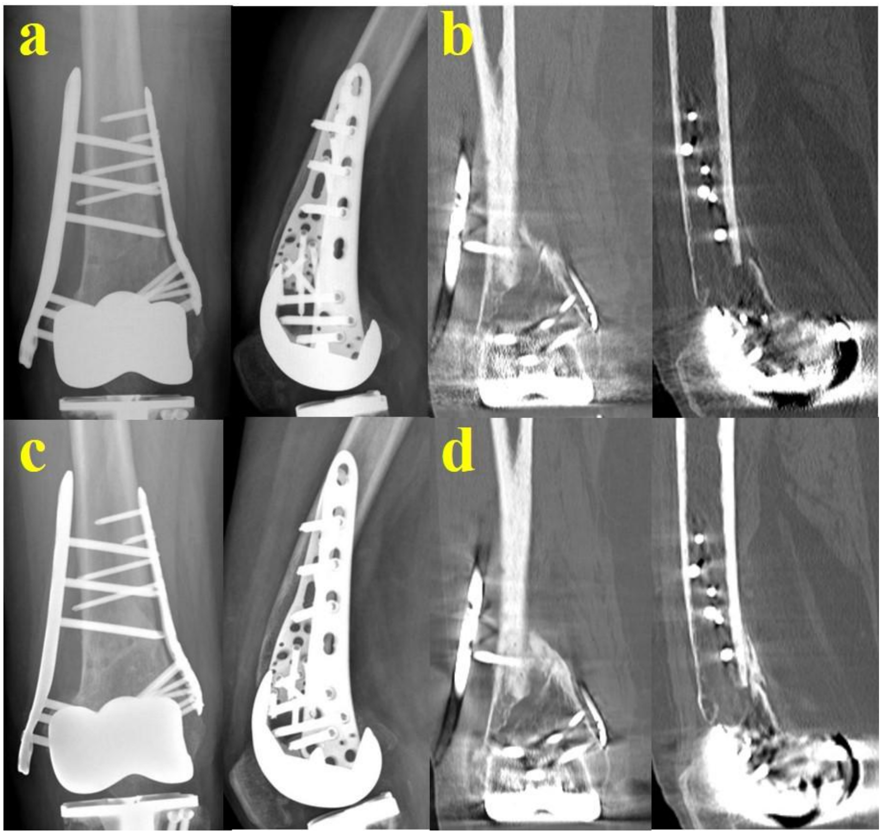
Demographic and fracture characteristics

Not only baseline demographic characteristics such as age, sex, height, weight, body mass index (BMI), diabetes, chronic steroid user, rheumatoid arthritis and mechanism of injury, but also fracture characteristics such as open/closed, AO/OTA classification(24) for non-periprosthetic fractures, Rorabeck(25)/Su(5) classification for periprosthetic fractures and fracture comminution were recorded. In this study, we defined the fracture comminution as 'loss of buttress effect on medial or lateral cortices after reduction'.

Radiographic evaluation and parameters

In this study, we defined 'bone union' as callus bridging across the fracture site that was visible on sagittal, coronal reconstructed CT images at two or more cortices. We also used RUSH (radiographic union score for hip)(26) score to supplementarily define bone union when RUSH score ≥ 15. We recorded 'union time (weeks)' strictly because we confirmed 'bony union' by CT scan. CT scans have advantages on detection of bone bridge. It is not easy to evaluate bone bridging by 2 orthogonal radiographs because two plates and several screws hid cortical surface and interfere to evaluate bone bridging. (Figure 1) Therefore, criteria of union in this study would be stricter than that of previous studies because we confirmed union only when both CT and radiographic criteria were met.

Figure 1. Advantages of CT scan to evaluate progression of bone bridge



a. Postoperative 3 months AP and lateral radiographs. It is difficult to clearly identify fracture gap by these radiographs.
b. Postoperative 3 months CT scan coronal and sagittal cuts. Fracture gap is easily detectable

on CT scan.
c. Postoperative 5 months AP and lateral radiographs. There is no significant change from figure 1 a.
d. Postoperative 5 months CT scan coronal and sagittal cuts. (Most similar views with figure 1 b) Progression of bone bridging is easily detectable on CT scan.

Nonunion was defined as no sign of bone healing until 9 months after surgery. Delayed union was defined as a condition in which there was evidence of some degree of bone healing but was not completely healed at six months post-operatively.

Mechanical lateral distal femoral angle (mLDFA) at pre-injury, immediate postoperative, post-operative 3 months and the last follow-up radiograph were measured to analyze the changes of femoral mechanical axis. We defined 'varus collapse angle' as the amount of mLDFA increased from immediate postoperative to certain follow-up point. Mechanical failure such as varus collapse was defined as >5° change of alignment at the coronal plane from immediate post-operative.

Clinical parameters

Clinical outcomes included knee range of motion, walking ability evaluated by Koval score(27), knee society score (KSS) and knee functional score(28) of at least postoperative 1 year. The need for reoperation and complications such as infection, mechanical failure and nonunion were also reviewed.

Statistical analysis

Between-group comparisons of demographic and fracture characteristics for continuous variables were analyzed by t-test, Wilcoxon rank sums test or Kruskal-Wallis (K-W) test. And Fisher's exact test were used for categorical variables.

Within-group comparisons of the radiographic parameter (mLDFA) before surgery and at each follow-up point were analyzed by paired t-test. Between-group comparisons of surgical outcomes (union time, varus collapse angle, final mLDFA, KSS, ROM) were analyzed by paired t-tests and K-W tests. A p-value <0.05 was defined as statistically significant. In multiple comparisons, we defined p-value <0.05 divided by number of comparisons as statistically significant by Bonferroni correction.

Results

Patient and fracture characteristics

Mean age at operation was 71.1 years and the average follow-up period was 36.9 months (range, 12-138 months). 86% of patients (93% in group P, 75% in group N) were aged 60 or more. There was no significant statistical difference between two groups in demographic and injury characteristics except for gender, ISS score and the proportion of high energy injury. (Table 1) More female patients were included in group P, and more high energy injuries were included in group N. All open injuries were included in group N.

Table 1. Comparison of demographic and injury characteristics between two groups

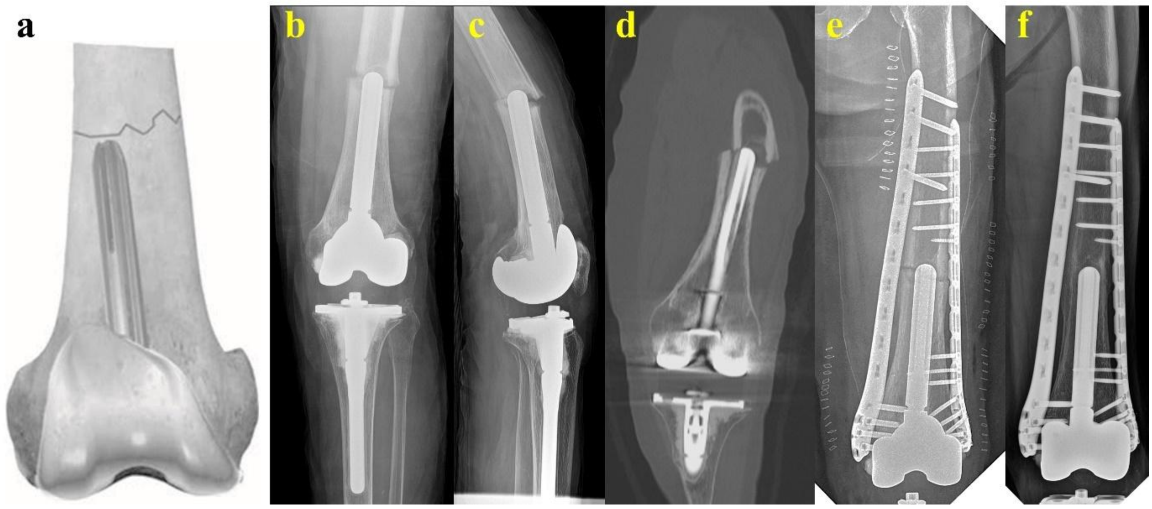
	Periprosthetic (n = 29)	Non-periprosthetic (n = 20)	P-value
Age, years	73.0±7.8	68.2±12.1	0.126
(range)	(52, 85)	(35, 85)	
Sex: female, number (%)	28 (96.6%)	15 (75%)	0.035
Follow up period, months	39.7±37.2	32.9±22.5	0.967
(range)	(12, 138)	(12, 75)	
Open wound, number (%)	0 (0)	3 (15)	0.062
ISS (injury severity score)	9.3±1.7	10.4±2.7	0.032
Diabetes, number (%)	14 (48)	7 (35)	0.356
BMI, kg/m²	25.0±2.7	24.9±2.9	0.933
Osteoporosis (%)	13 (45)	7 (35)	0.492
BMD, spine	-1.7±1.3	-1.8±1.3	0.711
(range)	(-3.8, 0.6)	(-3.3, 0.4)	
BMD, hip	-1.9±0.9	-1.9±1.2	0.844
(range)	(-3.6, -0.6)	(-3.5, 0.5)	
Pre-injury ambulation score by Koval et al*	1.1±0.3	1.1±0.5	0.611
Low energy, number (%)	27 (93)	13 (65)	0.022
High energy†, number (%)	2 (7)	7 (35)	

*Koval score(27) : walks independently (1), walks with aids (2), requiring a wheelchair (3), bedridden (4)

† Estimated amount of energy exceeds the fall above one's height.

In group P, all 29 patients presented closed fracture and Rorabeck type 2 fractures. According to Su classification, there were 2 patients of type I, 4 patients of type II, and 23 patients of type III. There were 2 cases of revision stem, which were classified into Su type I. (Figure 2) Comminution was observed in 48% of group P patients: no case in Su type I, 50% in Su type II and 52% in type III fractures. On average, 9.3 distal screws were inserted. Mean plate length (holes) were 6.0 holes in medial and 7.2 holes in lateral. Mean working length (holes) were 2.1 holes in medial and 2.5 holes in lateral.

Figure 2. 86-year-old female patient treated with double plating for Su type I periprosthetic fracture

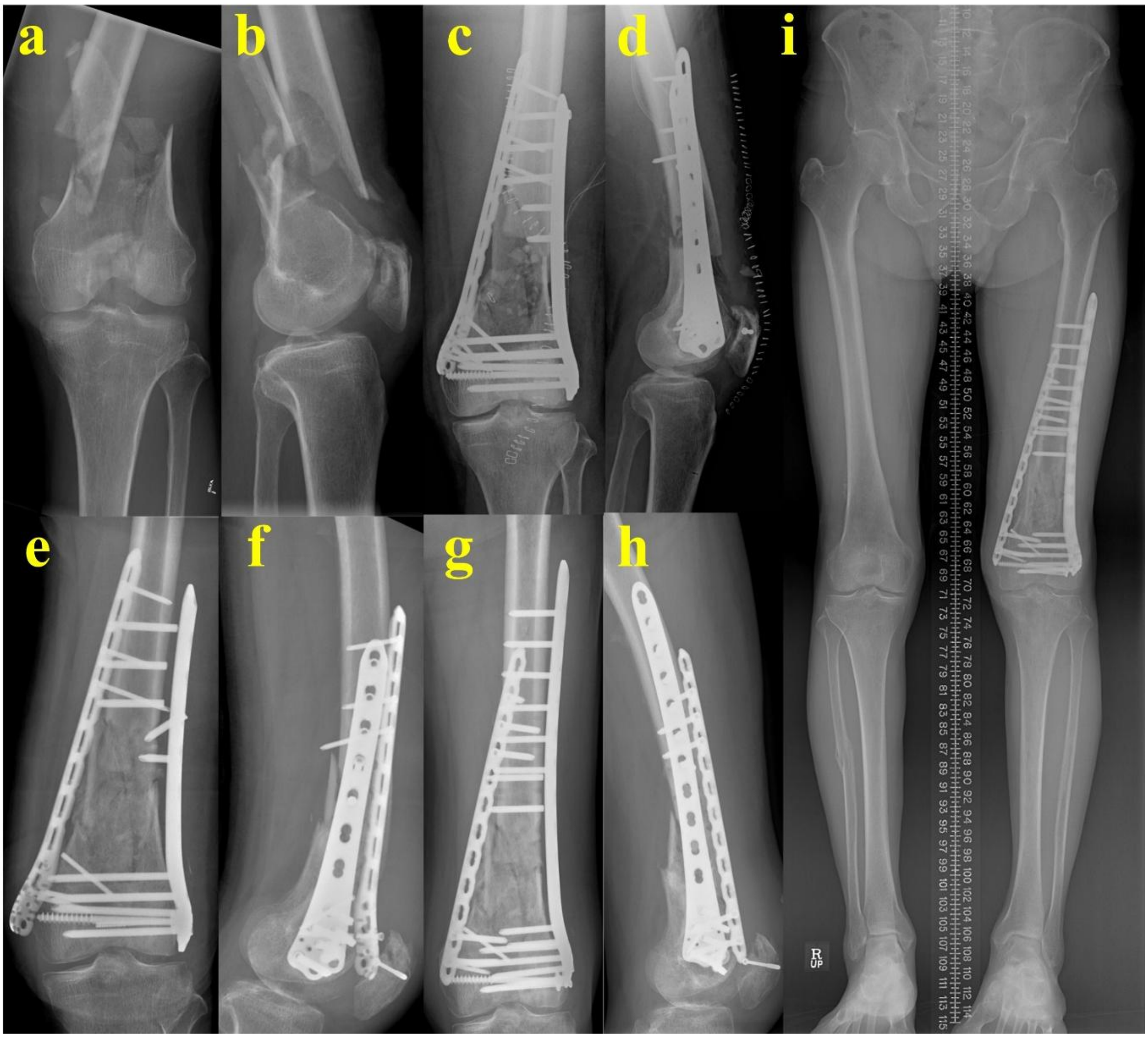


a. Illustration of transverse fracture occurring around the tip of the stem attached to the revision implant.(Right knee) Adapted with courtesy of Rhee et al.(29)
b, c. Preoperative AP and lateral radiograph. (Left knee)
d. Preoperative CT scan. Coronal cut.
e. Immediate postoperative AP radiograph. Long dual plates were used due to poor bone stock of distal segment.
f. Postoperative 3 years AP radiograph.

Among 20 patients of group N, 75% were aged more than 60 years and 35% were high energy injuries. Only 2 patients presented AO/OTA 33A3 fractures. The other 18 patients showed 33C fractures. Subtypes of 33C fractures and number of patients in each subtype are described in parentheses as follow: C1 (3), C2 (14), C3 (1). Comminution was observed in 85% of group N patients. Only three cases of C1 subtype fractures showed no metaphyseal comminution. And they were osteoporotic far distal fractures in old-aged patients who were aged more than 70 years. Two of them had severe osteoporosis by bone mineral density (BMD), one of them had proximal femoral stem due to previous hip surgery.

There were 3 cases of open fracture in group N: 1 case of Gustilo type 1 and 2 cases of Gustilo type 2. In Gustilo type 2 fractures, we performed autologous bone graft at the time of definitive fracture surgery after soft tissue and infection control. Despite such efforts, they needed secondary operation. First, 58-year-old male patient with open Gustilo type 2 AO/OTA 33C2.3 fracture achieved bony union with good mechanical alignment after secondary bone graft surgery. However, another 69-year-old male patient needed revisional fixation due to mechanical failure. (Figure 3) After revisional fixation, mLDFA was restored to 90°. Knee and functional scores were 95 and 100 respectively. Final knee range of motion was checked 130°.

Figure 3. 69-year-old male patient with Gustilo type 2 AO/OTA 33 C2.2 fracture



a, b. Initial AP and lateral radiographs. (Left knee) Lateral open wound was placed at the level of severe metaphyseal comminution.

c, d. Immediate postoperative AP and lateral radiographs. Debridement and dual locking plate fixation was performed. After 4 weeks from initial surgery without any sign of infection, auto bone graft was performed to fill bony defect.

e, f. Postoperative 3 months AP and lateral radiographs. Metal failure was occurred after minor slip down.

g, h. AP and lateral radiographs after revisional fixation. Revisional fixation was performed with longer plates.

i. Whole lower bone standing AP radiograph at postoperative 14 months from revisional surgery.

Surgical outcomes

Bony union was achieved in 47 patients (96%). However, 47% of the patients showed delayed union. Mean±SD union time was 36.2±22.1 weeks. Mean±SD RUSH score at final follow-up were 19.9±3.7 in group P and 19.1±2.9 in group N. There was no significant difference between groups in union rate and union time. (Table 2)

The mean mLDFA were restored to 90.5° (group P) and 87.7° (group N) after operation and were maintained to 90.5° (group P) and 88.3° (group N) until final follow-up. And final 'varus collapse angle' on average were -0.1° in group P and 0.6° in group N. Changes of mLDFA and varus collapse angle by time in each group were plotted in figure 4. And there was no significant statistical difference between two groups. ($p = 0.533$ in mLDFA, $p = 0.640$ in varus collapse angle)

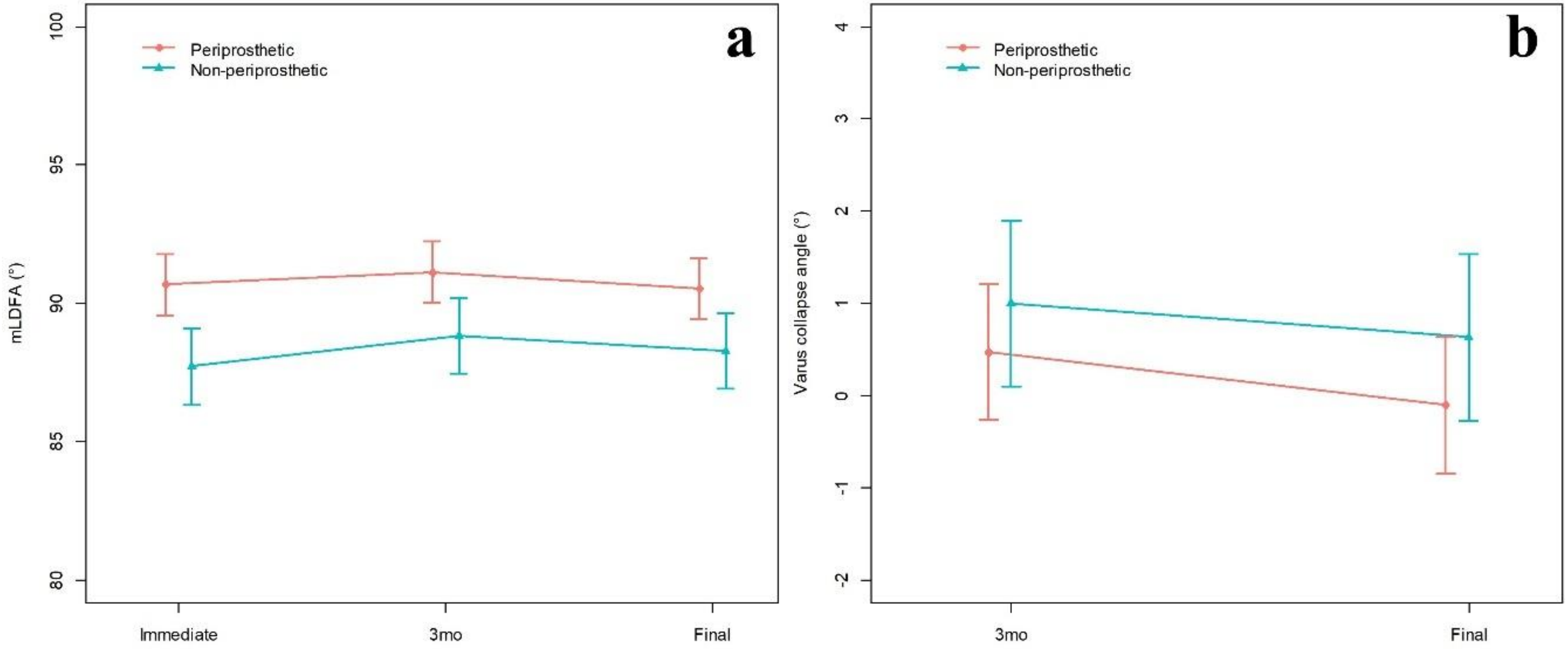
Final knee range of motion arc angle at average were 130° in group P and 107° in group N. ($p = 0.14$) Final Koval score at average were 1.7 in group P and 1.8 in group N. Final KSS knee score at average were 73.8 in group P and 87.1 in group N.

Table 2. Comparative outcomes between periprosthetic and non-periprosthetic fractures

Number (%)	Periprosthetic (n = 29)	Non-periprosthetic (n = 20)	P-value
Final union type (%)			
Non-union	1 (3)	1 (5)	1.000
Delayed union	14 (48)	9 (45)	
Union	14 (48)	10 (50)	
Time to Union, weeks	33.8±14.3	39.6±30.8	0.736
(range)	(12, 60)	(13, 110)	
Time to Full Weight Bearing, weeks	23.4±10.7	22.7±11.7	0.759
(range)	(5, 52)	(12, 50)	
Return to OR (%)	4 (14)	2 (10)	1.000
Mechanical failure (%)	1 (3.5)	1 (5)	
Junctional fracture (%)	1 (3.5)		
Symptomatic hardware (%)	2 (7)		
Delayed union (%)		1 (5)	
mLDFA (immediate post, °)	90.5±2.9	87.7±2.3	
mLDFA (3 months, °)	91.2±3.1	88.7±2.0	
mLDFA (final, °) *	90.5±3.5*	88.3±2.1*	
Varus collapse angle (°)	-0.1±2.0	0.6±2.1	0.212
KSS knee score (final)	73.8±18.1	87.1±11.9	0.019
KSS functional score (final)	52.6±30.1	55.7±37.2	0.777

*We excluded final mLDFA of mechanical failure cases. (One patient in each group)

Figure 4. Mean and standard error plots of mLDFA and varus collapse angle in each group by follow-up periods.

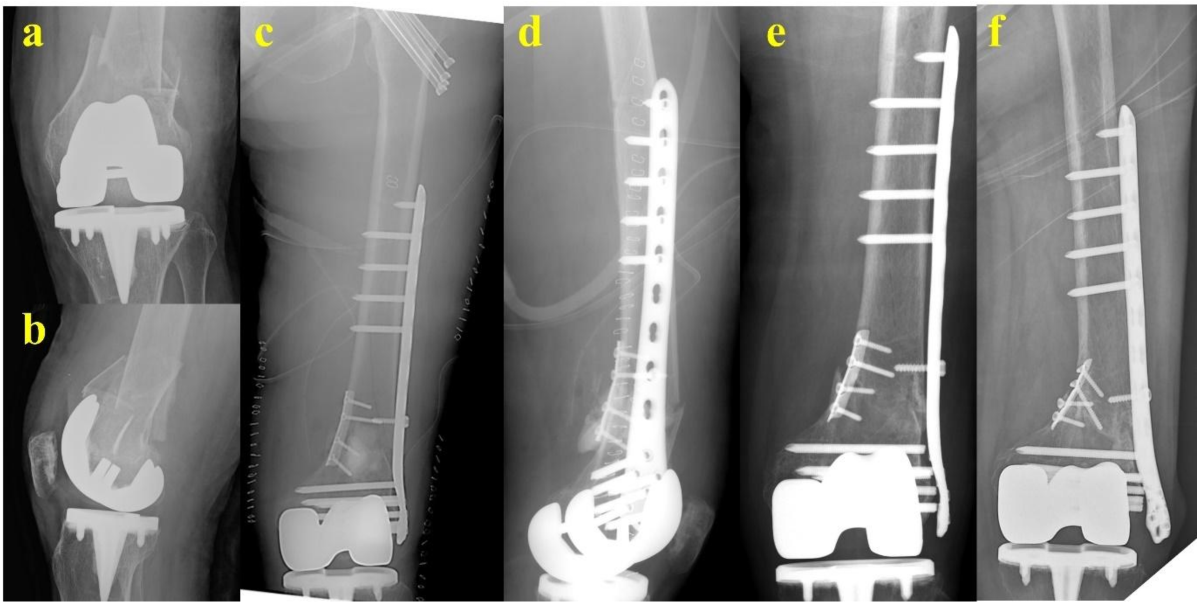


a. mLDFA (°)

b. Varus collapse angle (°)

There were 2 cases of mechanical failure: one of each group. (Figure 3, 5) And they couldn't achieve bony union at final follow-up despite secondary surgery. There were 6 cases (12%) of secondary surgery: 1 case of nonunion, 2 cases of implant failure, 1 case of junctional fracture after slip down and 2 cases of implant removal due to symptomatic discomfort. However, there was no case of TKA implant revision or total knee surgery after ORIF. And there was no case of infection.

Figure 5. 73-year-old female patient in group P with mechanical failure



a, b. Initial AP and lateral radiographs. Lateral cortex was severely comminuted

c, d. Immediate post-operative AP and lateral radiograph. Long lateral locking plate and posteromedial one-third tubular plate were fixed.

e. Post-operative 18 months AP radiograph. Varus collapse and mechanical failure were noted.

f. Post-operative 2 years AP radiograph. Golf club deformity with non-union was noted.

Discussions

In this study, dual plate osteosynthesis for both periprosthetic and non-periprosthetic distal femur fractures showed satisfactory radiographic outcomes with low complication rate: 96% achieved bony union with good mechanical alignment. And two groups showed similar surgical outcomes with each other. Park et al reported excellent outcomes after double plate fixation in 21 cases of Su type III PPDFFs.(23) In the study, 20 out of 21 patients (95%) achieved union and mean mLDFA was 89°, which was similar radiographic outcomes with ours in periprosthetic group. A few previous studies had focused on promising surgical outcomes of dual plate osteosynthesis for Su type III PPDFFs or comminuted native distal femur fractures.(17, 23) However, we reviewed dual plate osteosynthesis in both periprosthetic and non-periprosthetic (native) distal femur fractures with larger sample size. Recent nation database study reported similar short-term outcomes of PPDFFs and native distal femur fractures (NDFFs).(30) Another recent meta-analysis about dual plating of femur reported similar bone healing rate of PPDFFs (88.5%) and NDFFs (88.0%). And overall complication rates in the study were 21.9% in PPDFFs and 33.3% in NDFFs.(31) To the best of our knowledge, this is the biggest radiographic analysis of dual plating in periprosthetic and non-periprosthetic distal femur fractures.

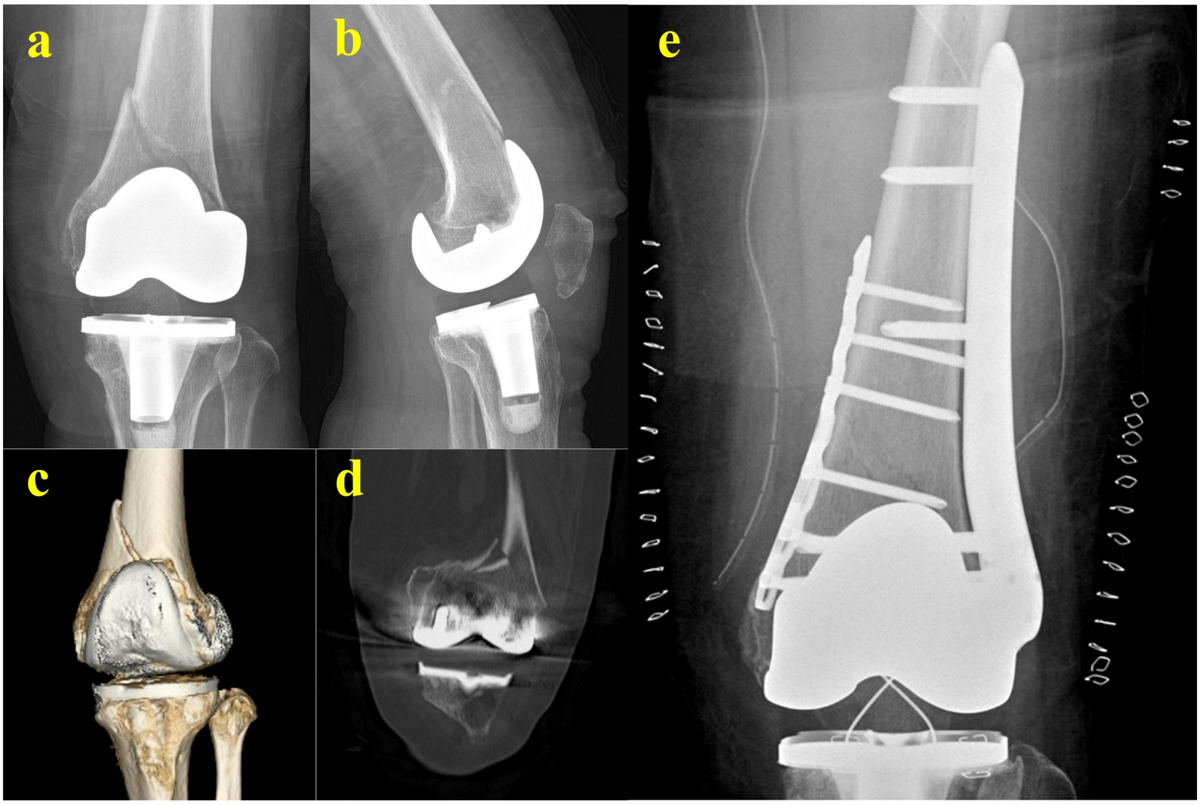
In this study, union rate was 96%, but union time was 34 weeks in group P and 40 weeks in group N. The results were quite longer than previous studies which reported average time to union ≤20 weeks. (16, 23) There can be several possible reasons. At first, the different definition and evaluation method were applied in this study. Our criteria of union would be stricter than that of previous studies because we confirmed union only when both CT and radiograph criteria were met. Secondly, dual plate construct was too stable to permit micromotions between fracture fragments.(21) Because locking plate osteosynthesis is based on indirect bone healing, least micromotion of too rigid construct could delay union process. In this study, rigid double plate construct could affect small number of mechanical failures but also affect longer union time. Thirdly, medial plate could affect vascular insufficiency for fracture healing. Recent cadaveric injection study showed possible scenario that medial periosteal arteries can be compressed by medial plating of distal femur.(22) Any vascular insults could potentially affect bone healing after dual plating.

In both groups, good mechanical alignment was maintained until final follow-up. To achieve neutral mechanical alignment, we usually set ideal target of mLDFA to 90° for periprosthetic fractures and 87° for native distal femur fractures. In this study, mean±SD mLDFA at immediate postoperative were 90.5±2.9° in group P and 87.7±2.3° in group N, which means overall successful reduction. And mLDFA were also maintained to 90.5° (group P) and 88.3° (group N) until final follow-up. Furthermore, mean varus collapse angle converged to 0° in both groups. In majority of patients, we achieved not only appropriate postoperative alignment but also maintenance of alignment without varus collapse until final follow-up. And the overall changes of mLDFA and varus collapse angle by time were similar between two groups.

Mechanical failure after surgery was occurred only in 2 patients (4%). 73-year-old women in group P showed gradual varus collapse and mechanical failure. (Figure 5) Short medial plate was not enough to maintain medial buttress effect. The other patient in group N had Gustilo type 2 open fracture with severe comminution. (Figure 3) Although mechanical failure occurred after slip down, short lateral plate would be a reason considering relatively long zone of comminution. Comminuted fractures are typically treated with longer bridging constructs where the plate length is at least twice the zone of comminution and four well-spaced bicortical screws are placed in the proximal shaft.(32)

In this study, mLDFA was well-maintained until final follow-up with very low rate of mechanical failure. Considering it is difficult to maintain fixation construct with a single plate in these types of fractures, additional plating would have strengthened stability. Dual plating was performed to reinforce stability in the poor bone stock and to avoid varus collapse in the comminution. At first, considering poor bone stock, not only 23 cases of Su type III fractures but also 2 cases of Su type I fractures with revision (long) stem had limited (poor) distal bone stock. For them, it was difficult to insert distal screws with a single plate as enough to gain stability. Not only Su type III periprosthetic fractures, but Su type I fractures in this study achieved successful surgical outcomes after dual plate fixation. (Figure 2) Furthermore, dual plating for non-periprosthetic (native) far distal fractures especially with elderly porotic bones showed good results despite the poor bone stock to acquire enough stability. Secondly, considering comminution, native distal femur fractures with metaphyseal comminution showed good results with dual plating despite no medial bony buttress effect after reduction which could led to varus collapse.(33) And among 27 patients of Su type II or III periprosthetic fractures, 14 (52%) cases had comminution in medial or lateral metaphyseal cortices: medial 7 (26%), lateral 10 (37%), both 3 (11%). And they also showed satisfactory limb alignment until final follow-up. And, interestingly, we could find a fracture category for indication of dual plating which is characterized by medial oblique fracture with large medial beak and shallow or comminuted lateral cortex on femoral implant. 6 Su III and 1 Su II fractures in this study could be categorized to this 'Medial oblique fracture' type. (Figure 6) In this type of fractures, stable distal screw fixation with single lateral plate is technically difficult due to poor bone quality of lateral cortices. We think medial buttress effect for large medial femoral beak is important for stable fixation because medical cortices have better bone quality.

Figure 6. Example of a new fracture category (Medial oblique fracture) which is characterized by large medial beak and shallow lateral cortex on femoral implant.



a, b. Example of 'Medial oblique fracture' type. Initial AP and lateral radiographs. (Left knee) Fracture line crosses anterior flange reverse obliquely and ends at far distal lateral location.

c, d. Initial 3D reconstruction image and coronal view of 3D CT. Large medial beak and limited lateral bone stock are noted.

e. Postoperative AP radiograph. Large medial beak was reduced and buttressed by medial plate.

Functional outcomes in both groups were both satisfactory. Knee range of motion was slightly better in group P (130°) than group N (107°). (p=0.14) However, group N showed better knee scores than group P. (Group P 73.8, Group N 87.1, p=0.019) And average walking ability by Koval score was similar at final follow-up. (Group P 1.7, Group N 1.8) Despite non-periprosthetic group had more severe injuries, underlying knee disability and relatively older age of periprosthetic group would affect the results.

This study has several limitations. The study retrospectively analyzed the heterogenous groups with a small sample size and short-term follow-up. To enroll large sized sample as possible, we set the period of patient enrollment about 12 years which could mean the heterogenous sample and technique. However, we think our study will provide one of the largest empirical data to surgeons who are in difficulties to choose dual plate osteosynthesis in distal femur fractures. Distal femur fractures are not common, but they are increasing and challenging injuries in geriatric population. Therefore, much larger prospective studies are required to analyze the indication and outcome of dual plating.

Conclusions

Dual plate osteosynthesis showed satisfactory radiographic outcomes with a low rate of complications in patients with PPDFFs or NDFFs. Despite different fracture and demographic characteristics, PPDFFs and NDFFs had comparable radiographic outcomes after dual plate fixation. Dual plate osteosynthesis is a promising surgical option for distal femur fractures with poor bone stock or comminution.

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국문 요약

연구배경: 이 연구는 원위 대퇴골 골절에서 이중 금속판 고정술의 결과를 보고하고, 인공 슬관절 주변 원위 대퇴 골절과 인공 삽입물이 없는 골절을 비교하기 위해 시행되었다.

연구방법: 이 연구는 후향적 코호트 연구로, 인공 슬관절 주변 원위 대퇴 골절과 인공 삽입물이 없는 AO/OTA 33 형 골절에서 이중 금속판 고정술의 결과를 분석하였다. 2008 년 7 월부터 2020 년 9 월까지 이중 금속판 고정술을 시행 후 1 년 이상 추적관찰이 가능했던 총 49 명이 연구에 포함되었으며, 인공 슬관절 주변 골절 그룹(P) 29 명과 인공 삽입물이 없는 골절 그룹(N) 20 명으로 나뉘었다. 나이, 성별, 체질량지수, 수상기전, 골절 형태 등과 같은 기본 정보가 수집되었고, 방사선학적 지표로는 골유합 기간, 역학적 외측 원위 대퇴각, 내반 변형각이 이용되었다. 임상적 지표로는 슬관절 가동범위, Koval 점수를 이용한 보행정도, 슬관절 점수가 사용되었다. 재수술 여부와 감염, 기계적 합병증, 불유합 등의 결과도 분석에 이용되었다.

연구결과: 수술 당시 평균 연령은 71.1 세였고, 평균 추적관찰 기간은 37 개월 (범위, 12-138 개월)이었다. 골유합은 전체의 96%인 47 명 (P 28 명, N 19 명)에서 확인되었으며, 평균 골유합 기간은 P 그룹에서 34 주, N 그룹에서 40 주로 확인되었다. 외측 원위 대퇴각은 마지막 추적 관찰 시 P 그룹에서 90.5°, N 그룹에서 88.3°로 확인되었다. 슬관절 가동범위는 P 그룹에서 130°, N 그룹에서 107°로 확인되었으며, 최종 슬관절 점수의 평균값은 P 그룹에서 73.8, N 그룹에서 87.1 로 확인되었다. 감염이 확인된 사례는 없었지만, 전체의 12%인 6 명의 환자에서 재수술이 필요했다. 재수술의 이유로는 불유합 1 명, 고정 실패 2 명, 낙상 후 변연부 골절 1 명, 금속물로 인한 불편감으로 제거 2 명이였다.

연구결론: 이중 금속판 고정술은 원위 대퇴골 골절에서 만족할 만한 골유합과 하지 정렬을 얻었고 합병증의 발생은 적었다. 전반적인 수술의 결과는 인공

슬관절 주변 원위 대퇴골 골절과 인공 삽입물이 없는 원위 대퇴골 골절에서 유사했다.