Original Article

Surgical outcomes of non-periprosthetic distal femur fragility fractures treated with a locking plate

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Background: Management of distal femur fractures can be challenging, particularly in the aged female population. This retrospective study aims to analyze the surgical outcomes of aged female patients with non-periprosthetic distal femur fractures treated with a locking plate.

Methods: This is an IRB approved retrospective review conducted at a level 1 trauma center. Fifty-five female patients (mean age of 71 years) with non-periprosthetic distal femur fractures underwent open reduction internal fixation using a locking plate from 2005 to 2019. The average follow-up time was 67 weeks from the date of injury. Criteria used for diagnosis of nonunion included one or more of the following: (I) three consecutive months without progression of healing on postoperative radiographs, (II) a total of nine months postoperative without complete healing, or (III) the physician diagnosed nonunion using clinical judgement. Outcome data was analyzed and compared amongst patients with and without obesity or diabetes. Statistical analysis was performed utilizing Microsoft Excel 2022 Data Analysis ToolPak with a standard statistically significant P value of <0.05.

Results: Thirty-two patients (58%) with distal femur fractures achieved union after initial treatment while 23 patients (42%) were diagnosed with nonunion. Fourteen patients (61%) underwent revision with 9 of these patients (64%) achieving union while 5 patients (36%) had persistent nonunion. Average healing time from initial treatment to union was 29 weeks, while average time from definitive treatment to union was 22 weeks. Obese patients [body mass index (BMI) >30 kg/m^2] had a nonunion rate of 65%, while non-obese patients had a nonunion rate of 28%. Patients with diabetes had a nonunion rate of 65%, while patients without diabetes had a nonunion rate of 28%.

Conclusions: Union can be successfully achieved in aged female patients with distal femur fractures treated with locking plates; however, the risks for nonunion and revision remain high. Patients with obesity and diabetes appear to be at an increased risk of nonunion (P=0.008 and 0.008, respectively). However, further research should be conducted with a prospective study or multivariate analysis and increased number of patients to reaffirm this data.

Keywords: Distal femur; fracture; aged female; locking plate; outcomes

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Introduction

Distal femur fractures are relatively common injuries that can involve the intercondylar and supracondylar regions of the femur. Distal femur fractures represent approximately 1% of all fractures and 3–6% of femur fractures and have an incidence of 37 per 100,000 people in the United States (1-3). These fractures have a bimodal age distribution, typically occurring in one of two populations. Fractures in younger patients are most commonly result of high energy trauma such as motor vehicle collisions. Distal femur fractures in elderly patients, however, are typically due to lower energy injuries such as ground level falls (1).

Distal femur fractures are commonly comminuted and involve the articular surface which makes proper reduction and alignment a difficult task (4). These cases are made even more challenging as they often occur in aged female patients who have likely undergone menopause, a population predisposed to osteoporosis and osteopenia. These patients, who are also at a higher risk of other comorbidities associated with elderly populations, can make the management and healing of distal femur fractures a challenging prospect.

Primary treatment methods used in the management of distal femur fractures are locking plate, intramedullary nail, double locking plate and total knee arthroplasty (4-6). At this time, operative guidelines regarding approach and implant choice are controversial and are typically surgeon dependent.

In this retrospective study, patients with distal femur fractures were initially treated with open reduction and internal fixation (ORIF) using a single lateral locking plate. While surgical outcomes of locking plates have been analyzed by other authors, there are currently no published studies specific to the aged female population (7,8). This study aims to analyze the surgical outcomes of aged female patients with distal femur fractures treated with a locking plate. We present the following article in accordance with the STROBE reporting checklist (available at https://aoj.amegroups.com/article/view/10.21037/aoj-22-15/rc).

Methods

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by Institutional Review Board of the University of Toledo (No. 301077) and individual consent for this retrospective analysis was waived. This retrospective study identified patients with distal femur fractures treated with locking plates at a level 1 trauma center from 2005 to 2019. A total of 55 female patients with distal femur fractures treated with locking plates with adequate follow-up were identified. Patients were excluded from this study if they had a periprosthetic fracture. The mean age of the patients at the time of injury was 71 years old. The causes of injury were identified as falls (48 patients, 87%), motor vehicle collisions (6 patients, 11%), and vehicle versus pedestrian (1 patient, 2%). Eight patients (15%) were smokers at the time of surgery, 23 (42%) were obese [body mass index (BMI) >30 kg/m^2], and 23 (42%) had diagnosed diabetes mellitus. All patients met these criteria were included and ruled out any potential selection bias in this study.

Surgical intervention was indicated if fractures exhibited significant displacement or poor alignment. Patients underwent surgery as soon as their general medical condition permitted. Preoperatively, patients were assessed with standard plain radiographs of the femur with two views (anteroposterior and lateral). Two dimensional CT of the lower extremity without contrast was often obtained to further evaluate for comminution and articular involvement. Intravenous (IV) cefazolin was administered prior to the operation, and vancomycin was used if the patient had a beta-lactam allergy. Deep vein thrombosis (DVT) prophylaxis included enoxaparin 40 mg daily.

Patients were placed in a supine position with a bump placed under the operative lower extremity. In cases of open fractures, the wound was thoroughly irrigated and debrided. The fracture site was identified with the aid of fluoroscopy in both the anteroposterior and lateral planes. Two separate longitudinal skin incisions, one distal and one proximal to the fracture site, were made over the lateral femur. Subcutaneous tissues were dissected to the level of the iliotibial band (IT band). The IT band was sharply incised at both the proximal and distal incisions to reveal the underling vastus lateralis. The vastus musculature was elevated off the surface of the femur to visualize the fracture site. Reduction was achieved with a combination of a bump, axial traction, and clamping.

A locking plate of appropriate size was then applied, and proper reduction and alignment were confirmed with fluoroscopy. A locking screw was then drilled, measured, and applied distally. A cortical screw was then drilled, measured, and applied proximally. Fracture alignment and reduction were again confirmed with anteroposterior (AP) and lateral fluoroscopy. The remaining distal holes were then drilled, measured, and filled with locking screws. The proximal holes

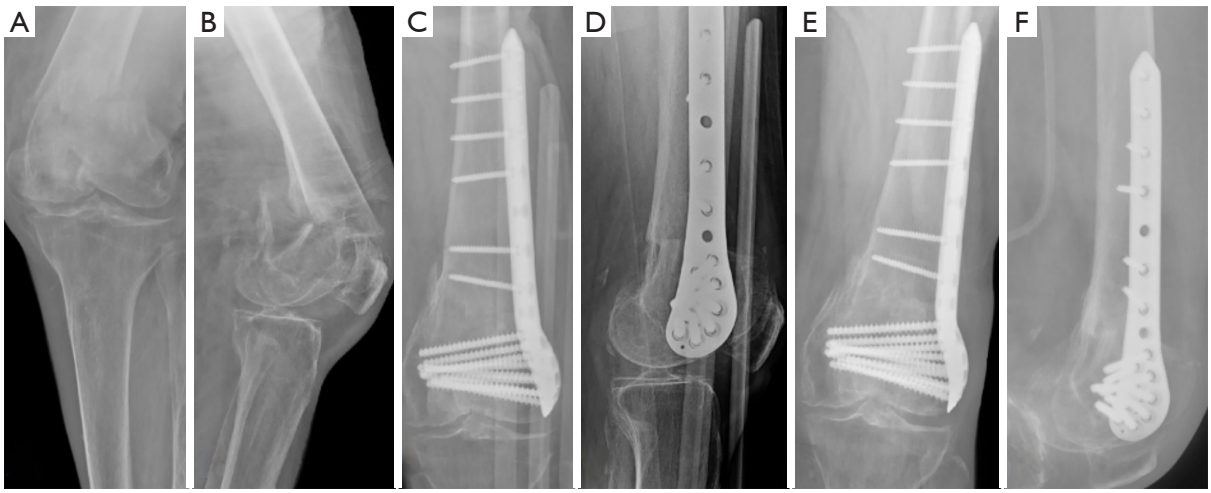

Figure 1 Type 33C3 fracture, 67-year-old female. (A) AP view preoperative; (B) lateral view preoperative; (C) AP view 2 weeks postoperative; (D) lateral view 2 weeks postoperative; (E) AP view 16 weeks postoperative (union); (F) lateral view 16 weeks postoperative (union). AP, anteroposterior.

were then drilled, measured, and filled with appropriately sized screws. Final AP and lateral fluoroscopic images were obtained, and the wound was irrigated and closed.

Postoperatively, patients were placed in a knee immobilizer to be worn for 4 weeks and were to remain non-weightbearing on the operative lower extremity. Patients received 24 h of IV antibiotics postoperatively and resumed DVT prophylaxis on postoperative day 1. Follow-up was scheduled at 2, 6, 10, and 16 weeks postoperatively, with additional visits scheduled as needed. The average follow-up time was 67 weeks from the date of injury. Knee range of motion was initiated at the first post-operative visit. Physical therapy and progression to full weight bearing was on an individualized basis.

Two view radiographs of the knee were taken at each postoperative visit to evaluate hardware, fracture alignment, and healing progression. A fracture was defined as healing appropriately when one of the following criteria were met: (I) the patient was progressed to greater than 50% weightbearing, (II) callus bridge on the fracture line was present on three-plane view in follow-up radiographs, (III) no pain was reported when the patient exceeded 50% weightbearing, or (IV) there were around three months of postoperative follow-up without concern for nonunion.

CT of the lower extremity was often obtained to further evaluate fracture healing if there was concern for nonunion. A fracture was defined as having evidence of nonunion when one of the following criteria was met: (I) the patient had three consecutive months with no progression of healing noted on postoperative radiographs, (II) a total of nine months postoperative without complete healing, or (III) the physician diagnosed nonunion using clinical judgment. Treatment options for patients diagnosed with nonunion included use of a bone stimulator, or revision with replacement of the existing plate, addition of a medial plate, and/or use of bone graft supplementation.

Time to union from initial treatment and definitive treatment were measured. Definitive treatment was defined as the most recent procedure prior to union. Other complications included malunion, hardware failure such as distal screw pullout, superficial infection, and symptomatic hardware.

Statistical analysis

Healing time was expressed as mean and standard deviation, and comparative statistical analyses were carried out by Student *t*-tests. Nonunion rate and revision rate were analyzed by the Chi-square test. P values <0.05 were considered significant.

Results

Thirty-two patients (58%) with distal femur fractures achieved union after initial treatment of ORIF with a locking plate (*Figure 1*). A total of 23 patients (42%) were

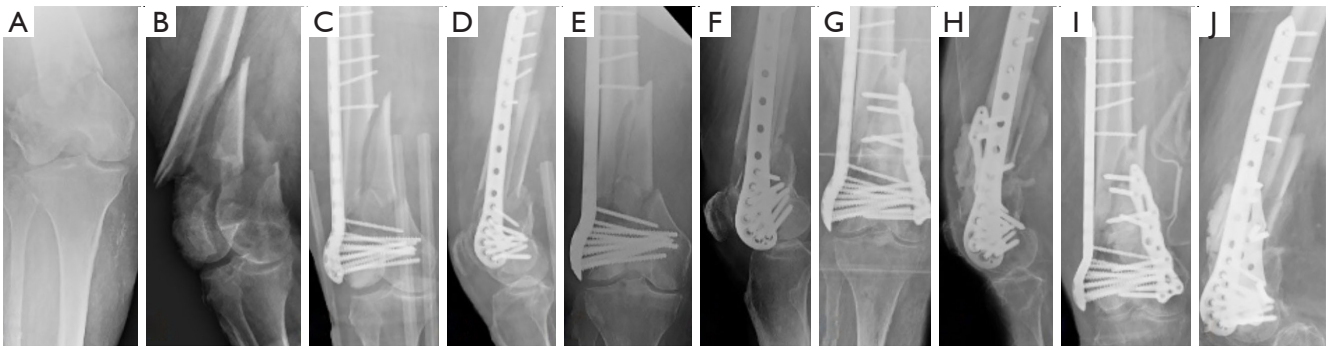

Figure 2 Type 33C2 fracture (open type IIIA), 67-year-old female. (A) AP view preoperative; (B) lateral view preoperative; (C) AP view 4 weeks postoperative; (D) lateral view 4 weeks postoperative; (E) AP view 16 weeks postoperative (nonunion); (F) lateral view 16 weeks postoperative (nonunion); (G) AP view 2 weeks post revision; (H) lateral view 2 weeks post revision; (I) AP view 14 weeks post revision (persistent nonunion); (J) lateral view 14 weeks post revision (persistent nonunion). AP, anteroposterior.

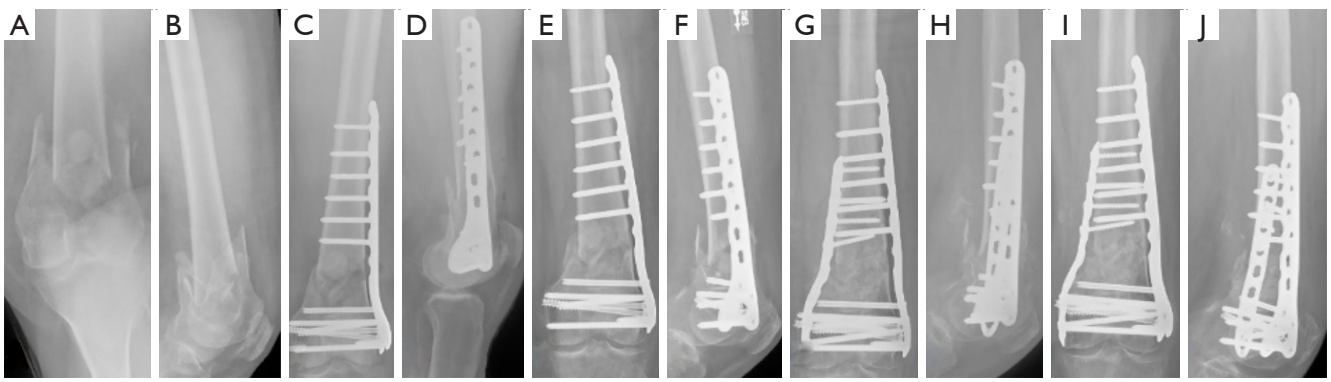

Figure 3 Type 33C2 fracture, 56-year-old female. (A) AP view preoperative; (B) lateral view preoperative; (C) AP view postoperative; (D) lateral view postoperative; (E) AP view 12 weeks postoperative (nonunion); (F) lateral view 12 weeks postoperative (nonunion); (G) AP view 2 weeks post revision; (H) lateral view 2 weeks post revision; (I) AP view 12 weeks post revision (union); (J) lateral view 12 weeks post revision (union). AP, anteroposterior.

classified as nonunion after initial treatment. Fourteen patients (61%) diagnosed with nonunion underwent revision after initial treatment. After revision, 9 patients (64%) achieved union while 5 patients (36%) had persistent nonunion (*Figure 2*). Average healing time from initial treatment to union was 29 weeks, while average time from definitive treatment to union was 22 weeks.

Three patients (5%) who experienced persistent nonunion underwent a trial of a bone stimulator prior to attempting surgical intervention. Revision for nonunion consisted of exchanging the existing locking plate with a new plate (1 patient, 7%), addition of a medial plate (3 patients, 21%), and/or supplementation with bone graft (13 patients, 93%) (*Figure 3*). Reoperation was also discussed in cases of hardware failure (2 patients, 9%) or symptomatic hardware (1 patient, 4%). Revision was not attempted in a total of nine patients with nonunion (39%) due to the patient declining further treatment (5 patients, 56%), the patient being lost to follow-up (2 patients, 22%), or the patient's general medical condition did not allow for further operations (2 patients, 22%).

The type of distal femur fracture was assessed using imaging (X-ray and/or CT) taken prior to surgical intervention and classified using the AO/OTA Fracture and Dislocation Classification Compendium types and groups (9). Thirty-four (62%) of the fractures were extraarticular (AO/OTA type 33A) while 21 (38%) fractures involved the articular surface (AO/OTA type 33C) (*Figure 4*).

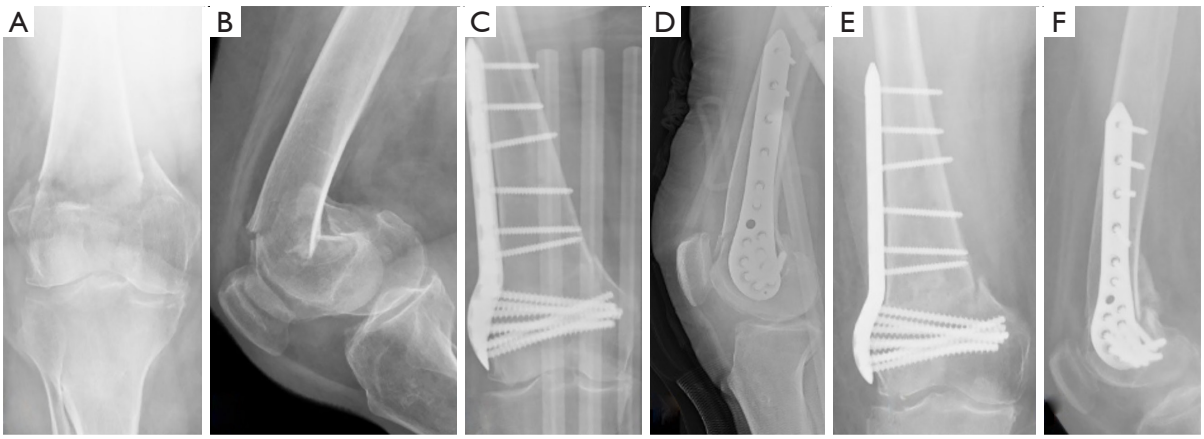

Figure 4 Type 33C3 fracture, 79-year-old female. (A) AP view preoperative; (B) lateral view preoperative; (C) AP view 2 weeks postoperative; (D) lateral view 2 weeks postoperative; (E) AP view 16 weeks postoperative (union); (F) lateral view 16 weeks postoperative (union). AP, anteroposterior.

Table 1 AO/OTA classification of fractures and surgical outcomes

AO/OTA type	Case number	Nonunion	Nonunion rate	Malunion	Hardware failure	Revision	Revision rate
33A1	8	4	0.50	1	0	3	0.38
33A2	7	4	0.57	0	0	1	0.14
33A3	19	6	0.32	0	2	5	0.26
33C1	3	0	0	0	0	0	0
33C2	10	4	0.40	1	1	3	0.30
33C3	8	5	0.63	0	1	2	0.25
Total	55	23	0.42	2	4	14	0.25

AO/OTA-AO is the premier innovator in the surgical treatment of bone fractures and disorders. OTA, Orthopaedic Trauma Association.

Table 2 Risk factors for nonunion

Risk factor	Odds ratio	Confidence interval	P
Current smoker	1.35	0.3–6.1	0.695
Obesity	4.79	1.5–15.2	0.008
Diabetes	4.79	1.5–15.2	0.008

Four patients (7%) were treated for open fractures (AO/OTA types I, II, IIIA, IIIA). Fracture distribution and surgical outcomes are presented in *Table 1*. A total of 8 patients (15%) were smokers at the time of surgery. Twenty-three patients (42%) were classified as obese (BMI >30 kg/m^2) at the time of intervention. Twenty-three patients (42%) had diabetes at the time of surgery. Current smokers in this study had a nonunion rate of 50%, while nonsmokers had a nonunion rate of 43%. Obese patients (BMI >30 kg/m^2) had a nonunion rate of 65%, while non-obese patients had a nonunion rate of 28%. Patients with diabetes had a nonunion rate of 65%, while patients without diabetes had a nonunion rate of 28%. Analysis of these comorbidities as risk factors for nonunion is summarized in *Table 2*.

Superficial infection occurred in 5 total patients (9%) that were treated with incision and drainage, with 3 (60%) of these patients having open fractures and 4 (80%) having diabetes at the time of presentation. The 5 infected cases were linked to non-union. Two patients (4%) experienced malunion (both in valgus alignment). Four patients (7%) experienced hardware failure, with 3 (5%) having the distal plate screw pullout and 1 patient (2%) having their distal locking plate bent in varus alignment. One patient (2%) experienced symptomatic hardware that was treated with

hardware removal. One patient (2%) had retained a drain tube that was surgically removed.

Discussion

Management of distal femur fractures continues to be challenging, particularly in the aged female population. These patients tend to have poor bone quality due to their age, postmenopausal changes, and an increased prevalence of comorbidities compared to a younger population which may interfere with the ability of hardware to properly fix to bone. Due to these factors, nonunion and revision rates remain high for these cases (9-12).

As this is a retrospective study without a control group for comparison there are limitations to the conclusions that can be drawn from this information. Also, because this study only analyzed patients that underwent ORIF with locking plates, these results may not apply to other treatment methods (13-16). Furthermore, it is important to note that the AO/OTA 33A1 fracture type is an avulsion fracture and outcomes should not be compared with the A3 or C types. We merely present this information as a method of further classification and additional preoperative data but recognize that conclusions cannot be drawn from comparison of the outcomes of A1 with A3 or C fracture types. This study also only examined postmenopausal females without periprosthetic fractures, therefore results from this study may not necessarily be generalized to all patients with distal femur fractures (17,18).

The nonunion rate in this study was determined to be 44%. A similar study by Ricci *et al.* analyzing 335 cases of distal femur fractures treated with locking plates found the rate of nonunion to be 19%. The patient population of this study included a younger population (age range of 17–97 years) and included male patients as well (45% male, 55% female) (7). The increased risk of osteoporosis and other comorbidities present in the aged female patient may help to explain the increased nonunion rates in this present study.

A proportion of 64% of patients who underwent revision for nonunion in this study went on to achieve union. The majority of these patients who underwent revision received bone graft supplementation. This may suggest that a lack of quality bone for hardware fixation during initial treatment may contribute significantly to the higher nonunion rates in the aged female population.

Healing times for this study from definitive treatment to union was calculated to be 22 weeks. A systematic review of distal femur fracture nonunion found that average healing time after definitive treatment was 7.8 months (31.2 weeks), suggesting time to union from definitive treatment in this present study is reasonable (10).

Patients with comorbidities in this study had an increased rate of nonunion. Obese patients and those with diabetes experienced significant increases in nonunion compared to patients without these comorbidities (P=0.008 and 0.008, respectively). Other studies of distal femur fractures also demonstrate an increase nonunion rate in patients with diabetes and obesity, suggesting the presence of these comorbidities can further increase nonunion rates in an already difficult case (7,8).

Conclusions

Management of distal femur fractures in the aged female population continues to be challenging. Union can be successfully achieved with locking plates; however, the risks for nonunion and revision remain high. In our study group, patients with obesity and diabetes experienced an increased risk of nonunion, suggesting that these factors may further increase the difficulty of these already complicated cases. Further research should be conducted with a prospective study or multivariate analysis and increased number of patients to reaffirm this data.

Acknowledgments

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://aoj.amegroups.com/article/view/10.21037/aoj-22-15/rc

Data Sharing Statement: Available at https://aoj.amegroups.com/article/view/10.21037/aoj-22-15/dss

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Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://aoj.amegroups.com/article/view/10.21037/aoj-22-15/coif). JL serves as an unpaid editorial board member of *Annals of Joint* from April 2022 to March 2024. The other authors have no conflicts of

interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by Institutional Review Board of the University of Toledo (No. 301077) and individual consent for this retrospective analysis was waived.

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