ORIGINAL PAPER/PŮVODNÍ PRÁCE

Dual Plating Through a Single Anterior Approach for Distal Femoral Fractures

Dvojité dlahování jedním předním přístupem u distálních zlomenin femuru

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ABSTRACT

Purpose of the study

Comminuted distal femoral fractures and very low periprosthetic fractures present significant treatment challenges, which are commonly associated with nonunion and varus collapse. Dual plating has emerged as an effective solution to address these issues. The aim of this study was to evaluate the clinical outcomes of osteosynthesis with double plates through a single anterior incision.

Material and Methods

Forty-nine patients (38 females, 11 males, mean age 65.7 ± 16.2 years, range 23–90 years) were included. The study comprised 18 acute distal femoral fractures (AO/OTA 33-C2/C3), 15 acute periprosthetic fractures (Su classification 2–3), and 16 distal femoral nonunions (13 with a history of acute distal femoral fractures and 3 with periprosthetic fractures). Demographic data, hospitalization time, follow-up duration, union time, and complications were assessed.

Results

The mean hospitalization time was 5.5 ± 3 days, with a mean follow-up of 13.6 ± 10.3 months (range 6–42 months). All fractures healed with a mean union time of 4.8 ± 1.6 months. Union times were 4.2 ± 1.5 months for distal femoral fractures, 4.1 ± 1 months for periprosthetic fractures, and 5.8 ± 1.5 months for nonunion fractures. Complications included one implant failure after a fall, one intraoperative vascular injury, and two superficial infections.

Conclusions

Dual plating through a single anterior incision is a reliable technique for comminuted distal femoral fractures, very low periprosthetic fractures, and distal femoral nonunion. It provides stable fixation, promotes early healing, and minimizes soft tissue complications.

Key words: distal femoral fracture, dual plating, anterior approach.

INTRODUCTION

Fractures of the distal femur are uncommon injuries that involve the supracondylar and intercondylar regions. They constitute approximately 0.4% of all fractures and 3% of all femoral fractures (2). These fractures demonstrate two peaks across the lifespan: the first occurs in younger individuals following high-energy trauma, while the second manifests in the elderly as a result of low-energy trauma (6).

Although noticeable advances in techniques and implants have been achieved, managing distal femoral fractures remains a challenging issue for orthopaedic surgeons. The management principles aim to achieve anatomical alignment, maintain an adequate blood supply, and ensure stable internal fixation, which is essential for enabling early rehabilitation. Lateral locked plating has been utilized for the management of comminuted distal femoral fractures (8). Minimal invasive techniques, such as retrograde nailing and minimally invasive plate osteosynthesis (MIPO) provide biological fixation and are primarily indicated for extra-articular distal femoral fractures (18). However, these methods have been associated with a notable incidence of complications, including nonunion, delayed union, malunion, and implant failure (7,18).

The dual plating technique has been described as an effective method for reducing complications associated with distal femoral fractures (29). Recently, dual plating has been shown to yield excellent results compared to single lateral plating (19). Additionally, this technique has been reported to facilitate healing following revision surgery for distal femoral nonunions by providing rigid fixation at the fracture site (9). Fixation failure and nonunion are less frequent in very low periprosthetic distal femoral fractures treated with dual plating compared to single lateral locked plating (14).

The aim of this study is to evaluate the clinical outcomes of osteosynthesis with dual plating in unstable, comminuted distal femoral fractures. Additionally, the study aims to assess the outcomes in very low periprosthetic distal femoral fractures and after revision surgeries for nonunion of these fractures.

MATERIAL AND METHODS

Approval for the retrospective analysis was obtained from the local institutional ethics committee (19-12T/37). Subsequently the medical records of patients who underwent osteosynthesis with double plating for distal femoral fractures, periprosthetic supracondylar femoral fractures, or nonunion revisions of these fractures were retrospectively reviewed. All procedures were performed by a single surgeon in the clinic between 2010 and 2023. Patients with pathological fractures, polytrauma patients, follow-up periods of less than 6 months, or incomplete data were excluded from the study. Only fractures classified as AO/OTA 33C2, 33C3, and Su types 2 and 3 were included. Anterior-posterior and lateral radiographs were obtained at the initial presentation. Computed tomography (CT) was performed when necessary. Demographic information, comorbid conditions, American Society of Anaesthesiologists (ASA) scores, injury mechanisms, fracture classifications, associated trauma, time to second surgery for periprosthetic and nonunion fractures, and complications were recorded. Acute distal femoral fractures and distal femoral nonunion fractures were classified using the AO Foundation/Orthopaedic Trauma Association (AO/OTA) system (23). Periprosthetic fractures were classified according to the Lewis and Rorabeck classification for supracondylar periprosthetic fractures proximal to total knee arthroplasty (17), and the Su classification (32). Open fractures were categorized using the Gustilo-Anderson classification (5). Follow-up duration, hospitalization time, time to union, revision surgeries, and complications were documented.

Surgical technique

Under epidural anaesthesia, patients were positioned supine on a radiolucent operating table to facilitate intraoperative fluoroscopy. A midline skin incision was used in all cases to access the distal femur. The surgical approach varied based on the type of fracture or prior surgeries. In acute distal femoral fractures and distal femoral nonunion cases, the subvastus approach was utilized to provide access to the articular surface and medial side while preserving the vastus medialis muscle. In periprosthetic distal femoral fracture cases, the medial parapatellar approach, commonly used in previous surgeries, was preferred to minimize dissection in scarred areas and access the medial side. The lateral side of the distal femur was approached via the anterior incision and retracting the vastus lateralis anteromedially. In cases requiring long lateral plates, proximal screw holes were accessed through small stab incisions to reduce soft tissue trauma. Reduction began with the articular surface in cases of intra-articular fractures. These were anatomically reduced and stabilized using lag screws to restore joint congruency. Fracture reduction commenced on the side with minimal or no metaphyseal comminution to optimize stability before addressing the more comminuted side. Careful attention was given to preserving the periosteum and avoiding unnecessary dissection, particularly around comminuted fracture lines, to minimize devascularization. Fixation involved the use of pre-contoured anatomical plates. On the lateral side, an anatomical locking distal femoral plate (Zimmer-Biomet Inc., Winterthur, Switzerland) was used. Proximal cortical screws were initially inserted to achieve alignment and control fracture reduction. On the medial side, an anatomical distal femoral osteotomy plate was used. Proximal cortical screws were again inserted first to accurately position the plate, followed by distal locking screws after achieving anatomical reduction. The sequence of plating depended on the direction of fracture displacement. When the distal fragment was displaced laterally, the lateral plate was inserted first, and vice versa. If the fracture remained insufficiently stable after applying the first plate, a few distal screws were inserted before placing the second plate. In distal femoral nonunion fracture cases, meticulous debridement of the fracture line was performed to remove fibrotic tissue and promote healing, although bone grafting was not conducted. Post-fixation, intraoperative fluoroscopy was used to confirm reduction quality, plate positioning, and screw placement. The procedure was completed with the placement of a suction drain to prevent hematoma formation. The extensor mechanism was repaired with the knee in 90° flexion to ensure optimal tension, and the subcutaneous tissue and skin were closed in layers using absorbable sutures.

Follow-up

During immobilization, low molecular weight heparin was administered for six weeks to prevent thrombosis. In the early postoperative period, patients underwent bed exercises without weight-bearing for the first six weeks. Partial weight-bearing was allowed after six weeks, and full weight-bearing commenced between 3 to 4.5 months. Follow-up assessments

Acta Chir Orthop Traumatol Cech., 93, 2026, No. 2, p. 86–93

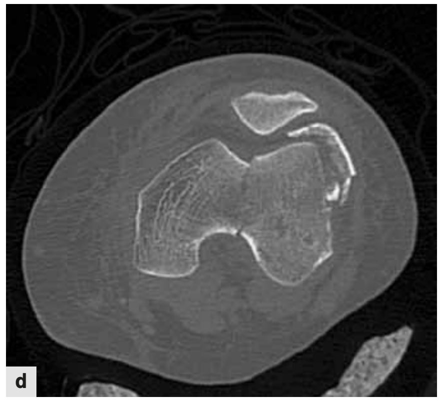
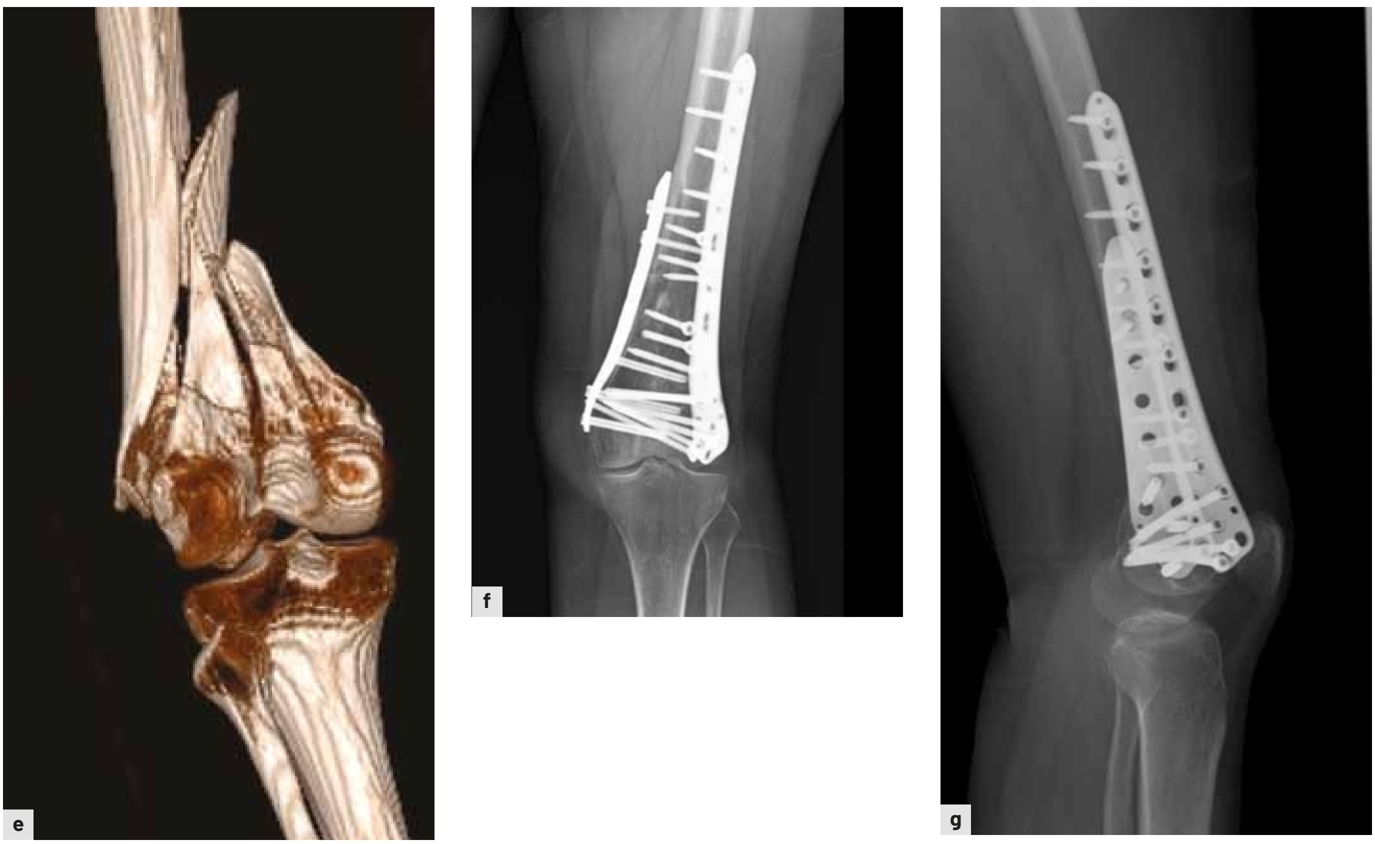


Fig. 1. **a – preoperative radiographs demonstrating an OTA/AO type 33-C2.3 distal femoral fracture with medial comminution and lateral displacement tendency. b, c, d, e – preoperative computed tomography (CT) images revealing simple articular involvement with a comminuted metaphyseal component. f, g – postoperative radiographs at 5 months showing evidence of fracture union with bridging callus formation medially, laterally, and posteriorly.**



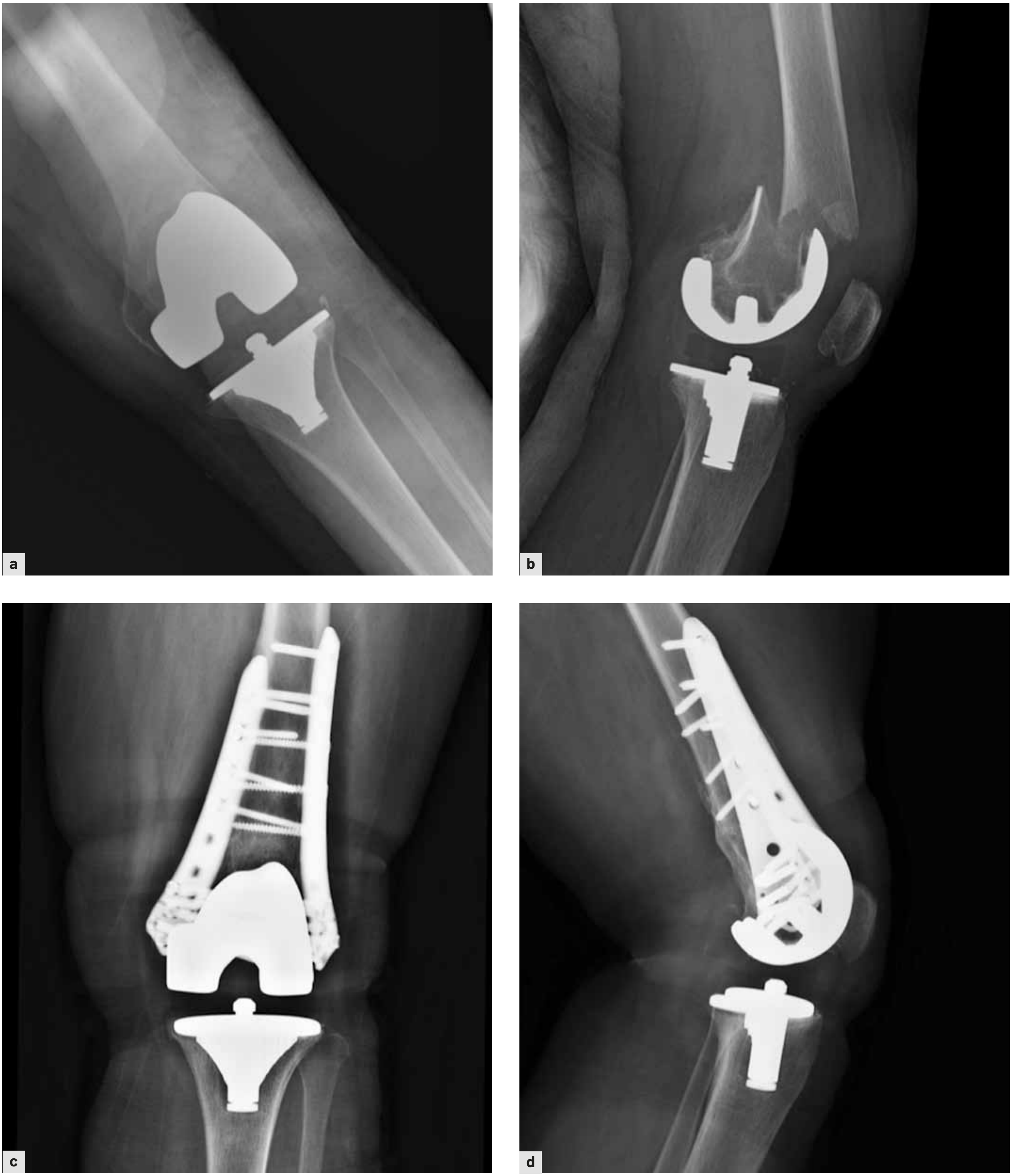


Fig. 2. **a, b – preoperative X-rays of the patient with periprosthetic fracture with Su classification type II. c, d – postoperative radiographs at 7 months confirmed union with medial, lateral, and posterior callus bridging.**

occurred at 3 weeks, 6 weeks, 3 months, 6 months, 9 months, and at 1 and 2 years postoperatively. Fracture union was confirmed radiologically by bridging callus formation across at least three cortices, and clinically by the patient's ability to fully bear weight without pain. Nonunion was defined as the absence of bony healing at least nine months postoperatively.

RESULTS

A total of 53 patients underwent osteosynthesis with double plating between 2010 and 2023. Four patients were excluded due to follow-up periods of less than 6 months, leaving 49 cases for analysis. This study included 18 acute distal femoral fractures, 15 acute periprosthetic supracondylar femoral fractures, and 16 aseptic distal femoral nonunion fractures. Among the nonunion cases, three followed revisions after periprosthetic distal femoral fracture surgery and 13 followed revisions after acute distal femoral fracture surgeries. The patient cohort consisted of 38 women and 11 men with a mean age of 65.7 ± 16.2 years (range: 23–90 years) and a mean follow-up period of 13.6 ± 10.3 months (range: 6–42 months). Hypertension was present in 67% of the patients, and 40% were diabetic. Acute distal femoral fracture group included seven AO/OTA 33-C2.2 fractures, six AO/OTA 33-C3.3 fractures, four AO/OTA 33-C2.3 fractures, and one AO/OTA 33-C3.2 fracture (Fig. 1). Distal femoral nonunion fracture after acute fracture included five AO/OTA 33-C3.3 fractures, four AO/OTA 33-C2.2 fractures, two AO/OTA 33-C3.2 fractures, and two AO/OTA 33-C2.3 fractures. Distal femoral nonunion fracture after periprosthetic fractures included two Su type 3 and one Su type 2 fractures. Periprosthetic distal femoral fracture group included 12 Su type 3 fractures and three Su type 2 fractures, all of which were displaced with no prosthesis loosening, corresponding to Lewis and Rorabeck Type II classification (Fig. 2). The mean time from total knee arthroplasty to fracture was 103.4 ± 70.7 months, and the mean time from initial fracture to re-operation in nonunion cases was 12.6 ± 4.7 months. Union was achieved in all cases. The mean time to union was 4.2 ± 1.5 months (range: 3–8 months) in the acute distal femoral fracture group, 4.1 ± 1.0 months (range: 3–6 months) in the periprosthetic distal femoral fracture group, and 5.8 ± 1.5 months (range: 4–9 months) in the distal femoral nonunion fracture group (Table 1). Union was achieved within 4 months for periprosthetic nonunions and within 6 months for nonunions following distal femoral fractures. Complications were encountered in several cases. Two patients, one in the acute fracture group and another in the nonunion group, developed superficial infections in the early postoperative period, which were successfully treated with debridement and antibiotics.

Table 1. **Demographics, classifications, and medical history of patients**

	ACUTE FRACTURE GROUP (N = 18)	PERIPROSTHETIC FRACTURE GROUP (N = 15)	NONUNION GROUP (N = 16)
Age (years)	65.8 ± 15 (43-90)	75.8 ± 6.9 (62-85)	56.1 ± 17.7 (23-82)
Female/male	14/4	14/1	10/6
Classifications			
AO/OTA 33 C2.2/C2.3/C3.2/ C3.3	7/4/1/6	N/A	*4/2/2/5
Gustilo-Anderson			
1/2/3	2/1/0	0/0/0	2/2/0
Su classification			
Su type 1/2/3	N/A	0/3/12	0/1/2
Comorbidities			
Diabetes mellitus	7	7	6
Hypertension	12	12	9
ASA score			
1	6	1	5
2	8	5	5
3	4	9	6
Injury mechanism			
low	14	15	7
high energy	4	N/A	9
Hospitalisation time (days)	4.8 ± 3.2 (2-15)	5.7 ± 2.6 (3-11)	6 ± 3.7 (2-16)
Union time (months)	4.2 ± 1.5 (3-8)	4.1 ± 1 (3-6)	5.8 ± 1.5 (4-9)

AO/OTA: The AO Foundation/Orthopaedic Trauma Association, ASA: American Society of Anaesthesiologists, data represented with mean ± SD and sample number. * Three cases were nonunion after periprosthetic fractures, two cases were Su type 3, and one case was Su type 2 fracture.

One patient in the acute fracture group experienced implant failure following a fall two months postoperatively; the plates were removed, fracture reduction was achieved, and dual replating was performed. Additionally, one patient in the periprosthetic fracture group sustained an intraoperative femoral artery injury due to improper Hohmann retractor placement, which was successfully repaired by a cardiovascular surgeon. All patients ultimately returned to their pre-fracture ambulatory status by the end of the follow-up period.

DISCUSSION

Comminuted distal femoral fractures and very low periprosthetic distal femoral fractures present significant treatment challenges due to the lack of consensus on the most effective fixation technique (15). Single lateral locking plates are commonly used in the management distal femoral fractures, providing angular stability through the locking mechanism between the screw heads and the plate. This system is particularly advantageous in cases of comminuted fractures and osteoporotic bone (25). However, nonunion rates of up to 20%, as well as malalignment rates of 26% in the coronal plane and 11% in the sagittal plane, have been reported (8). Minimally invasive techniques, such as retrograde intramedullary nailing and MIPO, offer the advantages of preserving bone vascularity and promoting fracture healing. The MIPO system has proven to be an effective treatment for distal femoral fractures, particularly in patients with poor bone quality, demonstrating low rates of infection, delayed union, and nonunion (30, 37). However, these methods are primarily indicated for extra-articular (Type A) fractures and are not suitable for managing complex intra-articular injuries. Furthermore, these techniques are technically demanding and have been associated with higher rates of malunion. Retrograde intramedullary nailing has been linked to anterior knee pain (18).

The double plating technique, first described by Sanders et al. in 1991 (29), has demonstrated consistent success in achieving fracture union. Several studies have reported average union times ranging from 3.5 to 6.7 months (3, 10, 27), with this study aligning with those findings: 4.2 ± 1.5 months for acute distal femoral fractures, 4.1 ± 1 months for very low periprosthetic fractures, and 5.8 ± 1.5 months for revised nonunion fractures. Importantly, none of the fractures in this study resulted in nonunion, consistent with previously reported low rates of 0–12.5% for double plating. However, meta-analyses indicate no significant difference in union rates between double plating and single lateral plating (34).

Complex AO/OTA C2 and C3 distal femoral fractures require precise anatomical reduction and rigid fixation for early mobilization. Surgical approaches to double plating often involve dual incisions, which, while providing adequate exposure, can risk medial dissection and subsequent complications (38). A single anterior midline incision, as used in this study, minimizes soft tissue disruption while offering superior joint visualization and fragment manipulation. Minimally invasive approaches have been shown to reduce the risk of infection but are associated with longer operative times and technical challenges (10, 33). Extensile approaches, like the Y-shaped incision, enhance visualization but increase risks of contractures and osteotomy site complications (12, 25).

Post-traumatic osteoarthritis rates after distal femoral fractures are reported to be as high as 36% (26). Moreover, future arthroplasty procedures via the third midline approach may carry a high risk of skin necrosis and infection. Thus, a single anterior midline incision was preferred in this study, providing excellent joint visualization and allowing precise manipulation of fracture fragments (10).

Maintaining adequate blood supply is essential for achieving favourable biological conditions, while mechanical stability ensures successful fracture healing (21). Disruption of vascularity following severe comminuted metaphyseal fractures is a well-known risk factor for nonunion (4). Rollick et al. reported a 21.1% reduction in distal femur vascularity after lateral plating (28). However, meticulous soft tissue dissection during medial plating does not appear to have any additional vascular compromising effects (19, 31). Notably, the absence of nonunion in this study supports the concept that, although dual plating via a single anterior approach may theoretically compromise blood supply, it does not appear to negatively impact the healing process.

Medial-sided approaches for distal femoral fractures carry the potential risk of vascular injury. Previous CT angiography studies have shown that this region is supplied by the third perforating artery to the vastus medialis muscle and the medial superior genicular artery (24, 31). Başarir et al. and Visser et al. identified the descending genicular artery entering at an angle of 20°–40° from the superomedial pole of the patella in cadaveric studies (1, 36). Avoiding vascular injury requires careful dissection, as these vessels are not directly adjacent to the bone. Steinberg et al. recommended extending the medial approach 5–7 cm from the medial condyle to reduce the risk of vascular injury (31). Kim et al. suggested safe medial plating up to 15 cm from the adductor tubercle to avoid injuring the posterior femoral artery, while a longer plate can be safely placed anteriorly up to 8 cm below the lesser trochanter (13). In this study, one intraoperative femoral artery injury occurred due to improper retractor placement, highlighting the importance of precise dissection and retractor placement within the safe zone.

Various implants, including humerus plates, reconstruction plates, locked L-plates, proximal and distal tibial plates, and femoral plates, have been used as medial plates for dual fixation of distal femoral fractures (19, 20, 22). While medial distal femoral osteotomy locked plates fit well on the proximal anterior quadrant of the medial femoral condyle, their limitations in trauma cases and risk of screw penetration into the notch make them less ideal (35). In biomechanical studies, Leung et al. found proximal tibia anterolateral plates to outperform proximal humerus plates in terms of medial condylar fit and fracture displacement at failure (16). Similarly, Upadhyay et al. reported that proximal tibia anterolateral plates provided the best fit and screw placement in the condylar quadrants (35). However, the femur's sagittal bowing (~9°) makes contralateral distal lateral femoral plates a better sagittal fit than proximal tibia plates (11). These findings underscore the need for anatomical medial femoral plates in varying sizes for trauma cases.

The limitations of this study include the small sample size, short-term follow-up, and inability to evaluate the impact of comorbidities or smoking on union time. Additionally, the absence of a control group limits the ability to directly compare our results; however, the primary objective of this study was to report the outcomes of dual plating in challenging distal femoral fractures. Future prospective, randomized controlled trials involving larger, multicenter cohorts are warranted to better evaluate the outcomes of various approaches for managing distal femoral fractures.

CONCLUSIONS

Dual plating through a single anterior incision proved to be a reliable and effective technique for the treatment of comminuted distal femoral fractures, very low periprosthetic fractures, and distal femoral nonunion fractures. This approach offered significant advantages, including enhanced exposure, precise manipulation for achieving anatomical reduction, and stable fixation, which facilitated early healing and minimized the risk of nonunion. Careful soft tissue dissection and attention to plating distance on the medial side were essential to reduce vascular injury risks, ensuring both safety and efficacy. ■

Ethics approval & consent: *This study was approved (19-12T/37) by the institutional review boards/Ethics Committees of Ege University Faculty of Medicine and was conducted in compliance with the ethical principles of the Helsinki Declaration of 1975.*
Consent to participate: *Informed consent was obtained from all individual participants included in the study.*
Consent to publish: *Patients signed informed consent regarding publishing their data and photographs.*

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