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Original Article

Comparison of retrograde intramedullary nailing, antegrade intramedullary nailing and distal femur locked plating methods in the treatment of extra-articular distal femur fractures: A retrospective analysis

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Abstract

Objective: Extra-articular distal femoral fractures account for 3% of femoral fractures, while they occur at a rate of 0.4% among all fractures. Although the basic treatment principles have not changed, the development of new implant designs for the biological fixation of this fracture is still ongoing. Among the treatment alternatives, internal fixation with anatomical plates and intramedullary nails are the most frequently utilized methods. Our objective in this research is to compare retrograde intramedullary nailing (RIMN), antegrade intramedullary nailing (AIMN) and distal femur locked plating (DFLP) methods in the treatment of extra-articular distal femoral fractures.

Methods: The study retrospectively examined the data of 48 patients who underwent locked plating for extra-articular distal femoral fracture, 40 patients who underwent retrograde intramedullary nailing, and 36 patients who underwent antegrade intramedullary nailing between 2016 and 2021. Patients who had pathological fracture, periprosthetic fracture, ipsilateral tibial fracture and fracture-associated ligament and neurovascular injury and open fracture were excluded from the study. Fractures were classified based on the classification of Arbeitsgemeinschaft für Osteosynthesefragen Foundation/Orthopedic Trauma Association (AO/OTA) for distal femoral fractures. Functional findings were assessed with respect to the criteria determined by Sanders et al. and Lysholm knee score criteria.

Results: The DFLP group included 48 patients (25 males and 23 females, aged 48.29±18.08 years), the RIMN group included 40 patients (19 males and 21 females, aged 49.93±18.31 years), and the AIMN group included 36 patients (15 males and 19 females, aged 46.22±18.6 years). There was no statistically significant difference between the groups in terms of age (p=0.727). The mean follow-up period was 26.04 months in the DFLP group, 25.9 months in the RIMN group, and 26.61 months in the AIMN group. The functional outcomes of the AIMN group were better than those of the other two groups based on the Sanders and Lysholm knee score criteria (p=0.001).

Conclusion: The results of our current study revealed that all three methods yielded good results. Nevertheless, better functional outcomes were obtained in patients who underwent intramedullary fixation compared to the DFLP group. We suggest AIMN as a reliable method in the treatment of extra-articular distal femoral fractures due to preferable knee joint functions, low bleeding rate and low complication rates compared to other fixation methods.

Keywords: Antegraded intramedullary nail, distal femur locking plate, femur distal fracture, retrograd intramedullary nail, orthopedics.

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INTRODUCTION

Distal femur fractures constitute 0.4% of all fractures, whereas they constitute 3% of femur fractures, having a bimodal incidence (1,2). These fractures are mostly seen in young adults following high-energy trauma and in elderly women following low-energy trauma (2). The occurrence of nonunion and infection complications observed in conventional open reduction and plating techniques for managing distal femur fractures has prompted experts to devise a biological fixing approach. Retrograde, antegrade intramedullary nailing, and bridge plating are widely utilized biological fixation techniques for the management of various types of fractures (3). Retrograde intramedullary nailing is commonly utilized in the treatment of extra-articular distal femoral fractures due to its low complication rates (1,4). The disadvantages of retrograde intramedullary nailing are that anterior knee pain may occur due to joint damage and systemic complications such as embolism may be encountered during the reaming procedure, particularly in patients with concomitant thoracic trauma (5,6). Bridge plating, which has become more common with the production of locked aligners today, allows limited fracture movement against physiological loads, causing external callus formation and providing good fixation in multipart distal femur fractures (7). Although this method uses lateral fixation, it reduces the risk of systemic problems such as knee problems and embolism that might occur due to the opening of the joint, and mobilization cannot be started by putting a load on the patient in the early period. Furthermore, problems such as implant fracture, delayed union and nonunion have also been reported (6,7). While the antegrade intramedullary nailing method is utilized more rarely in extra-articular distal femoral fractures than retrograde nailing and plate with distal femur locked plating methods, its use has increased thanks to new generation nail designs (8). There are many publications in the literature comparing retrograde intramedullary nailing and bridge plating, and no publication comparing the three methods has been reported.

In our study, we aimed to compare retrograde intramedullary nailing (RIMN), antegrade intramedullary nailing (AIMN) and distal femur locked plating (DFLP) methods in the treatment of extra-articular distal femoral fractures.

MATERIALS AND METHODS

Ethics committee approval

We obtained informed consent from the patients and conducted our study in accordance with the Helsinki Declaration after receiving permission from the Ethical Committee of the Noninvasive Clinical Research Ethics Committee of Gaziantep Islam Science and Technology University (09.21.2023-308).

Between 2016 and 2021, we retrospectively examined 48 patients (25 males and 23 females, aged 48.29±18.08 years) who had locked plating for extra-articular distal femoral fracture, 40 patients (19 males and 21 females, aged 49.93±18.31 years) who had retrograde intramedullary nailing, and 36 patients (15 males and 19 females, aged 46.22±18.6 years) who had antegrade intramedullary nailing after obtaining the consent of the local ethics committee. Patients without prefracture gait disturbance and with extra-articular acute distal femoral fracture participated in the study. Patients with pathological fracture, periprosthetic fracture, ipsilateral tibial fracture and fracture-associated ligament and neurovascular injury and open fracture were excluded from the study. Fractures were classified based on the classification of AO/OTA femoral distal fractures.

Surgical procedure

DFLP and RIMN procedures were performed in the supine position. The AIMN group patients were operated on in the lateral decubitus position. In the DFLP group, the distal femoral locking plate was implanted submuscularly proximal to the fracture line, approximately 5-6 cm lateral to the distal thigh line. To gain access to the plate, an incision was made approximately 5-6 cm lateral to the proximal thigh in the region corresponding to the proximal end of the fracture line. To secure the distal portion of the plate to the bone, a K-wire was utilized. The fracture was reduced by providing sufficient extremity length and alignment with manual traction, and the proximal portion of the plate was secured with a second K-wire. After radiographic confirmation of the reduction, the proximal and distal plates were secured with locking screws, completing the osteosynthesis. In the RIMN group, the joint was reached via a 4-5 cm long medial parapatellar approach. Using manual traction, the fracture was reduced by supplying length and alignment. After confirming the radiological reduction, the K-wire was positioned retrogradely at the

trochanter minor level of the femur, just anterior to the medial condyle attachment site of the posterior cruciate ligament. Subsequently, the femoral medulla was incised over the K-wire and a retrograde intramedullary nail was implemented. In all patients, osteosynthesis was completed by securing the nail with at least two lock screws distally and one lock screw proximally. In the AIMN group, the supracondylar fracture was reduced by applying traction to the fractured femoral condyles with a K-wire. Accompanied by C-arm fluoroscopy, the appropriately long intramedullary nail was driven until its distal tip reached the subchondral region. After distal locking with at least two screws, the proximal was locked. To prevent infection, all patients received antibiotherapy for 24 to 48 hours postoperatively and low molecular weight heparin for four weeks. Knee-hip-ankle exercises and isometric quadriceps strengthening were initiated at the end of the first postoperative day. On the second day, patients were mobilized with double aids without overloading the injured extremity. At week three for simple fractures and week six for complex fractures, partial overweighting was instituted in the follow-ups. Patients were evaluated for healing, operation and duration of hospital stay, functional outcome, amount of intraoperative bleeding, comorbidities and complications during postoperative follow-ups. According to the criteria established by Sanders et al. and the Lysholm knee score criteria, functional outcomes were evaluated. The Sanders criteria consist of five parameters that classify outcomes as exceptional, good, moderate, or poor based on knee range of motion, pain, deformity, walking capacity, and return to work.

Statistical analysis

The analyses were performed using the SPSS v22.0 software. Compliance of the numerical data with a normal distribution was tested with the Shapiro Wilk test. Kruskal–Wallis and Dunn tests were utilized to compare nonnormally distributed variables in the three groups. The chi-square test was used to test relationships between categorical variables. Statistical significance was set at $p<0.05$ for all comparisons.

RESULTS

Patient characteristics

The DFLP group included 48 patients (25 males and 23 females, aged 48.29±18.08 years), the RIMN group included 40 patients (19 males and 21 females, aged 49.93±18.31 years), and the AIMN group included 36 patients (15 males and 19 females, aged 46.22±18.6 years). There were no significant differences between the groups in terms of age ($p=0.727$) and sex or side (Table 1). The mean follow-up period was 26.04 months in the DFLP group, 25.9 months in the RIMN group and 26.61 months in the AIMN group. Table 2 presents the fracture type distribution based on the AO/OTA classification.

Table 1. Demographic variables

		Implant			
		AIMN	DFLP	RIMN	
		n (%)	n (%)	n (%)	P
Sex	Male	17 (47.2)	25 (52.1)	19 (47.5)	0.877
	Female	19 (52.8)	23 (47.9)	21 (52.5)	
Side	Left	17 (47.2)	21 (43.8)	21 (52.5)	0.714
	Right	19 (52.8)	27 (56.3)	19 (47.5)	
Tobacco use	Yes	10 (27.8)	12 (25)	14 (35)	0.578
	No	26 (72.2)	36 (75)	26 (65)	

Abbreviations: AIMN: Antegrade Intramedullary Nailing, DFLP: Distal Femur Locked Plating, RIMN: Retrograde Intramedullary Nailing, *Significant at $p<0.05$ level, Chi-square test.

Table 2. The number of fractures within each group based on the AO/OTA classification for distal femur fractures

AO/OTA classification of distal femur fractures	AIMN	RIMN	DFLP
33A2	11	19	19
33A3	4	13	5
32A1c	5	2	4
32A2c	1	3	2
32A3c	3	1	4
32B2c	7	3	2
32B3c	4	5	1
32C3k	1	2	3

Abbreviations: AO/OTA: Arbeitsgemeinschaft für Osteosynthesefragen Foundation/Orthopedic Trauma Association, AIMN: Antegrade intramedullary nailing, DFLP: Distal femur locked plating, RIMN: Retrograde intramedullary nailing, c: for type 32A and 32B fractures distal 1/3 segment, k: for type 32C fractures distal diaphyseal- metaphseal segment.

Patients operated on with these three methods are compared in Table 3 on the basis of length of hospital stay, duration of operation, Charlson comorbidity index, additional surgical intervention, duration of healing, and amount of intraoperative bleeding. Table 4 shows the complications observed in the DFLP and RIMN and AIMN groups. Table 5 shows the comparison of the clinical functional outcomes between these three methods based on the Sanders criteria and Lysholm knee scores. The functional results of the AIMN group were better than those of the other two groups with respect to the Sanders and Lysholm knee score criteria (p=0.001).

Table 3. Comparison of the preoperative and perioperative processes of each group

	AIMN (n=36)	DFLP (n=48)	RIMN (n=40)	P
Duration of hospital stay (days)	5.64±2.34	5.85±2.12	5.78±1.99	0.739
Operation time (minutes)	77.92±13.33	88.54±16.88	88.75±14.49	0.001*
Charlson comorbidity index	1 (0-9)	2 (0-7)	2 (0-10)	0.827
Additional surgical intervention	0 (0-2)	0 (0-2)	0 (0-2)	0.026*
Healing time (months)	3.75±2.43	5.33±4.18	4.05±2.1	0.117
Intraoperative bleeding amount (ml)	563.33±113.54	628.54±118.57	462±113.37	0.001*

Abbreviations: AO/OTA: Arbeitsgemeinschaft für Osteosynthesefragen Foundation/Orthopedic Trauma Association, AIMN: Antegrade Intramedullary Nailing, DFLP: Distal Femur Locked Plating, RIMN: Retrograde Intramedullary Nailing, *Significant at $p<0.05$ level, Kruskal–Wallis test and Dunn test.

Table 4. Comparison of complications between groups

		Implant			
		AIMN	DFLP	RIMN	
		n (%)	n (%)	n (%)	P
Implant failure	Yes	0 (0)	6 (12.5)	3 (7.5)	0.029*
	No	36 (100)	42 (87.5)	37 (92.5)	
Nonunion	Yes	1 (2.8)	14 (29.2)	2 (5)	0.001*
	No	35 (97.2)	34 (70.8)	38 (95)	
Infection	Yes	4 (11.1)	6 (12.5)	4 (10)	0.986
	No	32 (88.9)	42 (87.5)	36 (90)	

Abbreviations: AIMN: Antegrade Intramedullary Nailing, DFLP: Distal Femur Locked Plating, RIMN: Retrograde Intramedullary Nailing, *Significant at p<0.05 level, Chi-square test.

Table 5. Comparison of Sanders criteria and Lysholm knee scores between groups

	AIMN (n=36)	DFLP (n=48)	RIMN (n=40)	P
Sanders critera	30.14±5.63	25.44±5.37	29.7±5.85	0.001*
Lysholm knee score	81.39±7.38	67.35±7.29	70.63±10.62	0.001*

Abbreviations: AIMN: Antegrade Intramedullary Nailing, DFLP: Distal Femur Locked Plating, RIMN: Retrograde Intramedullary Nailing, *Significant at p<0.05 level, Kruskal–Wallis test and Dunn test.

DISCUSSION

Bridge plating and antegrade and retrograde intramedullary nailing are biological fixation methods for the treatment of extra-articular distal femoral fractures. In spite of these modern fixation techniques, distal femur fractures may cause ongoing pain and disability. Therefore, it is controversial which fixation method is preferable today. The present study conducted a comparative analysis to evaluate the efficacy of AIMN, RIMN, and DFLP interventions, employing the Sanders criteria and the Lysholm Knee Scoring Scale as assessment tools. The AIMN group exhibited a significant superiority over the other groups in terms of functional outcomes.

In the literature, there are very few studies comparing biologically implemented intramedullary nailing and bridge plating in distal femoral fractures and published different findings. In a retrospective study of distal femur fracture cases treated with retrograde nailing and DFLP, Hoskins et al. reported that 95% of fractures in both groups healed within six months (8). Henderson et al. suggested in their retrospective study that the quantity of callus measured at week 12 following trauma was significantly less in the bridge plating group than retrograde nailing (9). In a retrospective study by Gill et al. comparing bridge plating and retrograde nailing methods applied to extra-articular distal femoral fractures, the nail group healed 4 weeks ago in terms of healing period, with no statistical significance (10). In our study comparing three treatment procedures, the mean healing period was 5.33 months in the DFLP group, 4.05 months in the RIMN group and 3.75 months in the AIMN group. Thus, the mean healing durations were similar in the three groups. (p=0.117). It aligned with the research of Gill et al. (10).

In the systematic study carried out by Zlowodzki et al. on 45 articles including 1670 distal femoral fractures, the nonunion rates were 8.3% for antegrade nails, 5.3% for retrograde nails, and 5.5% for bridge plating. The infection rates were 0.9% for antegrade nails, 0.4% for retrograde nails and 2.1% for bridge plating (11). In our study, the infection rates were 11.1% for antegrade nailing, 12.5% for retrograde nailing, and 10% for bridge

plating. The nonunion rates were 2.8% for antegrade nailing, 5% for retrograde nailing, and 29.2% for bridge plating. Salem et al. compared retrograde nailing and antegrade nailing in distal femoral fractures, assessing nonunion, infection, length, femoral alignment and function. Hip range of motion was restricted in antegrade nailing, and knee range of motion was restricted in retrograde nailing. There was no significant difference in other parameters (12). Hierholzer et al. reported less blood loss due to a smaller incision in retrograde nailing. Nonetheless, they suggested that there was no significant difference from the point of nonunion and infection rates in both fixation methods (13). In the study of Ocalan et al. comparing bridge plating and antegrade nailing methods in extra-articular distal femoral fractures, there was no significant difference in terms of infection and nonunion (14). Ziranu et al. advised to consider utilizing retrograde intramedullary nailing for revision purposes in instances of nonunion following plating in cases of intra-articular distal femur fractures, despite the presence of an intra-articular fracture (15). There are many studies on the surgical treatment of distal femoral fractures and there are few studies examining functional outcomes (16,17). In our study, there was no significant difference in the three methods in terms of infection. On the other hand, the rate of nonunion was higher in the DFLP group.

Reviewing the current literature, the implant failure rate was 9% in a large series of 101 patients treated with DFLP due to femoral distal fracture (18). Another study recommended DFLP to augment the medial column in patients to undergo DFLP due to high implant failure rates in unstable femoral distal fractures (19). In another study employing 44 patients with femoral distal fractures treated with DFLP, an early failure was observed at a rate of 13.6% (20). The implant failure rate (12.5%) was significantly higher in the DFLP group than in the intramedullary fixation group in our study.

Gao et al. compared retrograde nailing and bridge plating, revealing that the duration of surgery and the amount of intraoperative bleeding were significantly higher in the nailing group in 36 patients with extra-articular distal femur fractures (21). In our AIMN group, on the other hand, the duration of surgery and the amount of intraoperative bleeding were significantly less than those in the other two groups.

Numerous studies have been conducted to investigate surgical interventions for distal femoral fractures, but a limited number of studies have focused on evaluating the functional results associated with such treatments (16,17). In the study of Hierholzer et al. using Knee and Osteoarthritis Outcome Scoring, there was no significant difference between the two groups in terms of functional results at the end of an average 14-month follow-up (13). In the study of Demirtaş et al. using Sanders criteria, there was no difference between the two groups in terms of functional results (22).

In another study in which Gill et al. utilized the Knee Society score, there was no significant difference between retrograde nailing and DFLP groups in terms of functional outcomes (10). Hoskins et al. retrospectively examined 297 patients with distal femoral fractures using EuroQol-5 and revealed that the nail group was functionally better (8). Ocalan et al. compared the bridge plate and antegrade nailing method in extra-articular distal femoral fractures using the Lysholm Knee Scoring Scale. They found that the antegrade nailing group performed better in functional terms (14). In our research, where we compared AIMN, RIMN and DFLP using the Sanders criteria and the Lysholm Knee Scoring Scale, the AIMN group was significantly superior to the other groups in terms of function. The current literature indicates that achieving minimal soft tissue damage and stable fixation is of utmost importance in ensuring satisfactory clinical function (23-25).

Limitations:

The limitations of our study were the retrospective examination of a small number of patients and the exclusion of open fractures.

CONCLUSION

Posttreatment clinical outcomes and complications in femoral distal fractures depend on numerous factors, such as implant selection, open injury, fracture type, associated injuries, bone quality, and surgeon selection. Our findings revealed that all three fixation methods yielded good results. Nevertheless, the functional results of intramedullary fixation were significantly higher than those of the locking plate group. The AIMN group also had better functional results than the RIMN group. Although the antegrade nailing method has difficulty controlling

the distal fragment, we propose it as a reliable method in the treatment of extra-articular distal femur fractures due to better knee joint function, a low bleeding rate and low complication rates.

Conflicts of interest: The authors declare that no conflicts of interest.
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Peer review: Externally peer reviewed.
Ethical approval: Informed consent was obtained from the patients. We conducted our study in accordance with Helsinki Declaration after receiving permission of the Ethical Committee of the Noninvasive Clinical Research Ethics Committee of Gaziantep İslam Science and Technology University (09.21.2023-308)
Author contributions: Idea/Concept: NG, OK; Design: NG, VÖ; Control/Supervision: İHD; Data Collection and/or Processing: NG, VÖ, OK, İHD; Analysis and/or Interpretation: NG; Literature Review: OK, İHD; Writing the Article: NG, VÖ; Critical Review: OK, İHD

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