

Research Paper: Evaluation of the Outcome of Different Surgical Techniques in the Treatment of Distal Femur Intra-articular Fractures: A Retrospective Study



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ABSTRACT

Background: A preferred surgical approach to distal femur intra-articular fractures is still controversial.

Objectives: In the current study, we assessed the outcome and complications of three different surgical techniques, including screw fixation, Retrograde Intramedullary Nailing (RIN), and Locking Compression Plate (LCP).

Methods: A total of 63 patients with distal femur intra-articular fractures were included in this retrospective study. AO/OTA fracture and dislocation classification was used to categorize patients. Type B fractures were treated with screw fixation and type C fractures were treated using LCP and RIN. Outcome measures, including the knee range of motion (ROM) and pain level, were

Results: The Mean±SD age of patients was 36.7±15.7 years. The fracture types B and C were detected in 22 (32.4%) and 46 (67.6%) patients. The mean follow-up period was 27.2±15.9 months. Mild knee pain was the only complication of screw fixation that was observed in 21% of patients. LCP was associated with some complications, including pain (19.4%), infection (9.7%), limited ROM (47.4%), malunion (47.4%), and nonunion (6.5%). RIN was also associated with several complications, including pain (44.4%), infection (11.1%), limited ROM (33.3%), and malunion (41.2%). A comparison of the outcome in matched fracture types of LCP and RIN groups revealed no superiority of each technique.

Conclusion: Screw fixation alone results in a satisfactory outcome in the treatment of type B distal femur intra-articular fractures. LCP and RIN are associated with a variety of complications with no superiority over each other.

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1. Introduction

Fractures of the distal femur account for 4%-6% of all femoral fractures [1], which can be extra-articular or intra-articular [2, 3]. Intra-articular fractures occur in nearly 55% of cases [2]. These fractures occur either following a high-energy trauma in young adults or following a low-energy trauma in elderly with osteoporotic fragile bones [2]. Optimal restoration of the functional anatomy and stable fixation of these fractures are required to achieve a satisfactory outcome and early recovery. However, the fixation is generally difficult either due to the involvement of the articular surface or poor bone stock. Moreover, these fractures are associated with a high rate of postoperative complications, including infection, residual stiffness, post-traumatic osteoarthritis, and nonunion that may negatively affect the patient's quality of life [4, 5]. Therefore, optimization of the outcome of these fractures is of critical value. Intra-articular fractures of the distal femur are generally treated with Open Reduction and Internal Fixation (ORIF), and many devices, including screw fixation, Retrograde Intramedullary Nailing (RIN), and Locking Compression Plate (LCP) have been advanced for this purpose. Although these techniques have resulted in a satisfactory outcome, the rate of complication is still considerable, and there is no consensus regarding the superiority of either of the methods. Therefore, the treatment of the intra-articular fractures of the distal femur remains a challenge for orthopedic surgeons [6].

Descriptive studies reporting the outcome of different surgical approaches in the treatment of intra-articular distal femoral fractures could be considered as a valuable strategy to achieve a consensus on the optimal surgical technique. This study was done to report the outcome of surgical management of intra-articular fractures of the distal femur in a cohort of patients who underwent surgery through screw fixation, RIN, or LCN.

2. Patients and Methods

This research was approved by the institutional review board of Iran University of Medical Sciences (IR.IUMS. FMD.REC.1398.005). Also, and informed consent was obtained from all patients. Patients with an intra-articular fracture of the distal femur who were referred to the emergency department of our university hospital between 2011 and 2016 were evaluated retrospectively. The inclusion criteria were as follows: Those who under-

went surgical management and followed for a minimum of 12 months. Patients with delayed treatment (which is defined as surgery time of more than two weeks of injury) were excluded from the study. After the identification of eligible patients, they were called and asked to attend an evaluation session.

The demographic characteristics of the patients on admission, including age, gender, and Body Mass Index (BMI) were extracted from the patients' medical files. Surgical complications were extracted from the patients' records, as well. Fractures were categorized using AO/OTA system into three main groups: A (extra-articular fracture), B (partial articular fracture), and C (intra-articular fracture). Only patients with type B and C fractures were included in the study. Patients of both groups were then divided into three subsets, including B1 (sagittal plane fracture of the lateral femoral condyle), B2 (sagittal plane fracture of the medial femoral condyle), B3 (any frontal or coronal plane fracture of the condyle), C1 (simple articular split and metaphyseal injury), C2 (simple articular split with comminuted metaphyseal injury), and C3 (comminuted articular with varying metaphyseal injury) [7].

At the follow-up visit, functional and radiological outcomes were assessed by a single researcher. Clinical evaluation of the patients included knee Range of Motion (ROM) and pain. The pain was scored using a Visual Analog Scale (VAS) for pain ranging from 0 to 10 (0=represents no pain). Anteroposterior and lateral radiographs of the knee were obtained for the radiologic evaluation of outcome, including the assessment of union, degenerative changes, and mal-alignment. Generally, nonunion was defined as a failure to reach bony union (callus formation or trabecular bridging) by 6 months post-injury or not showing signs of healing for three months. Malunion was defined as the incomplete or faulty union or angulation and translation of fracture site visible on both AP and lateral radiographs compared with the contralateral limb.

Surgical procedure and postoperative protocol

All the surgeries were performed by one senior surgeon (A.B.). Screw fixation alone was used for the majority of type B fractures (Figure 1). When additional support of the fracture area was required, a plate (Figure 2) or nail was used for buttressing (Figure 3). The condylar plate was utilized where a plate was implemented. After the operation, a splint was applied to facilitate resting and wound healing. Physiotherapy and passive knee ROM were started as soon as possible. All patients were regularly followed at the outpatient clinic.

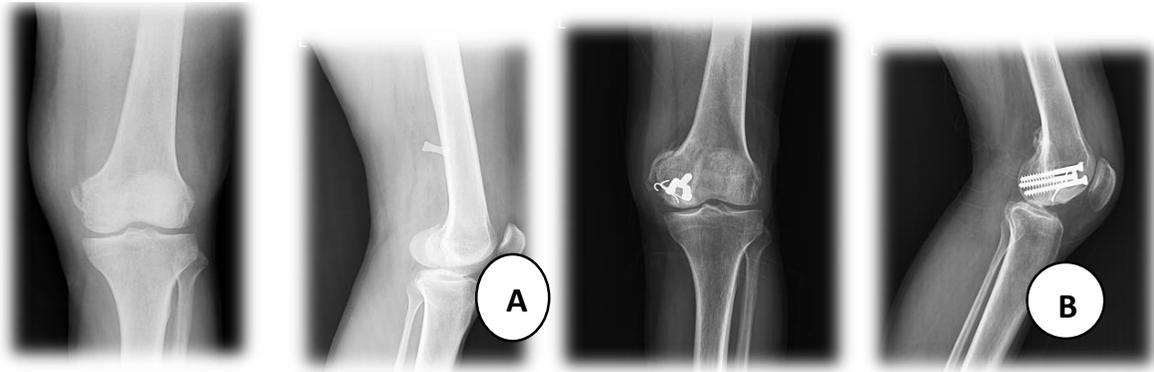


Figure 1. Radiograph of the distal femur fracture and screw fixation

A. Anterior-posterior and lateral radiograph of the injured left distal femur fracture; B. Anterior-posterior and lateral radiograph of the injured left distal femur after distal femur screw fixation.

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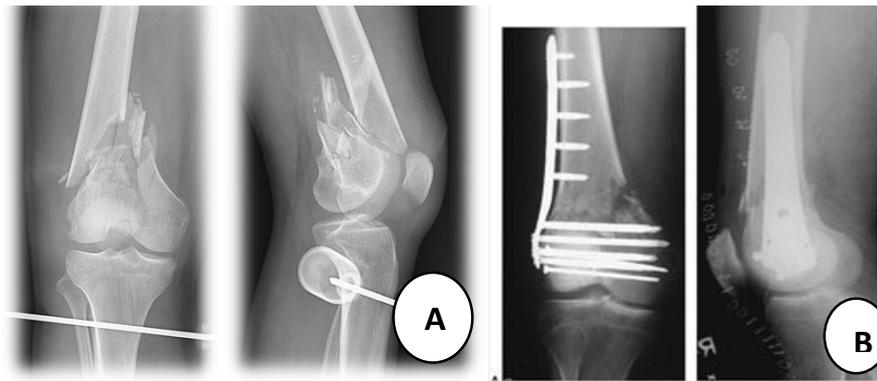


Figure 2. Radiograph of the distal femur fracture and plate fixation

A. Anterior-posterior and Lateral radiograph of the injured left distal femur fracture; B. Anterior-posterior and lateral radiograph of the injured left distal femur after distal femur plate fixation.

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Statistical analysis

SPSS v. 16 (Chicago, Illinois, USA) was used for the statistical analysis. Descriptive data are expressed as the mean and standard deviation. A comparison of the mean values between independent groups was performed us-

ing an independent t-test or its nonparametric equivalent (Mann–Whitney U test). A Chi-square test was used for the assessment of the difference between categorical variables. A p-value smaller than 0.05 was considered significant.

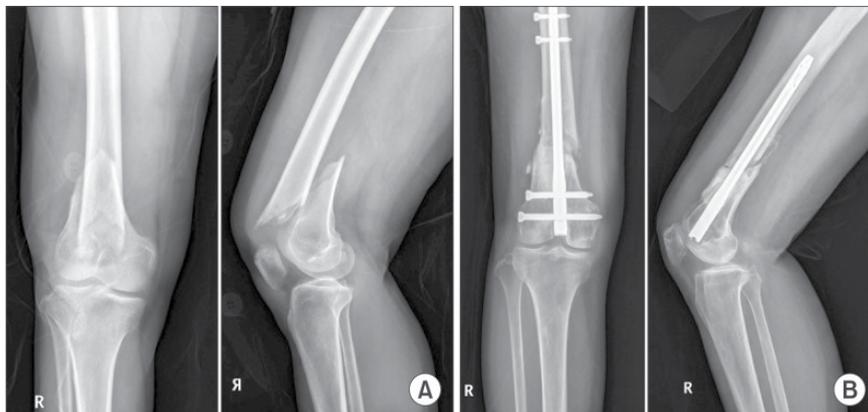


Figure 3. Radiograph of the distal femur fracture and RIN fixation

A. Anterior-posterior and lateral radiograph of the injured right distal femur fracture; B. Anterior-posterior and lateral radiograph of the injured right distal femur after distal femur retrograde nailing.

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3. Results

From a total of 96 patients who were eligible for this study, 68 patients (26 (38.2%) males and 42 (61.8%) females) with a Mean±SD age of 36.7±15.7 years (range: 21-58 years) attended at evaluation sessions. The etiology of injury was low-energy trauma in 32 (47%) patients and high-energy trauma in 36 (53%) patients. The Mean±SD follow-up period was 27.2±15.9 months (range: 12-45 months). The fracture types B and C were detected in 22 (32.4%) and 46 (67.6%) patients, respectively. Patients' demographic characteristics are summarized in Table 1.

The outcome of patients who were treated with screw fixation

Screw fixation was used in 19 (28%) patients, including 6 (31.6%) males and 13 (68.4%) females with a Mean±SD age of 32±6.7 years. The fracture type was B1, B2, and B3 in 7 (36.8%), 5 (26.4%), and 7 (36.8%)

patients, respectively. The Mean±SD number of physiotherapy sessions was 34.2±11.7 and the mean union period was 13.3±3.4 weeks. The mean ROM of the patients was 127.7±31.4°. Knee pain was reported in four (21%) patients. In these patients, the Mean±SD VAS score for pain was 1.9±0.7. No other surgical complications were reported in this group.

The outcome of patients who were treated with LCP

LCP technique was used in 31 patients (45.6%), including 13 (42%) males and 18 (58%) females with a Mean±SD age of 33.7±12.2 years. Fracture types B1, C1, C2, and C3 were identified in 3 (9.7%), 6 (19.4%), 14 (45.2%) and 8 (25.7%) patients, respectively. The Mean±SD union period was 18.7±5.8 weeks. The mean ROM was 103.7±27.1°. A limited ROM was recorded in 9 patients (29%). Knee pain was found in 6 patients (19.4%). The mean VAS of the patients with knee pain

Table 1. Characteristics of the patients who underwent surgery for the treatment of an intra-articular fracture of the distal femur

| Variables | | Mean±SD/No. (%) (n=68) |
|--------------------------|--------------------|------------------------|
| Age (y) | | 36.7±15.7 |
| Gender | Male | 26 (38.2) |
| | Female | 42 (61.8) |
| Etiology of injury | Low-energy trauma | 32 (47) |
| | High-energy trauma | 36 (53) |
| BMI (kg/m ²) | | 25.1±4 |
| Involved limb | Right | 39 (57.4) |
| | Left | 29 (42.6) |
| Type of fracture | B1 | 10 (14.7) |
| | B2 | 5 (7.4) |
| | B3 | 7 (10.3) |
| | C1 | 6 (8.8) |
| | C2 | 26 (38.2) |
| | C3 | 14 (20.6) |
| Surgical approach | Screw fixation | 19 (28) |
| | LCP | 31 (45.6) |
| | RIN | 18 (26.4) |
| Follow-up (month) | | 27.2±15.9 |

BMI: Body Mass Index; LCP: Locking Compression Plate; RIN: Retrograde Intramedullary Nailing.

Table 2. Complications associated with different surgical approaches in patients with an intra-articular fracture of the distal femur

| Variables | | No. (%) | | | |
|-------------------------|-----|-----------------------|------------|------------|-------|
| | | Screw Fixation (n=19) | LCP (n=31) | RIN (n=18) | Total |
| Pain | Yes | 4 (21) | 6 (19.4) | 8 (44.4) | 18 |
| | No | 15 (79) | 25 (80.6) | 10 (55.6) | |
| Infection | Yes | 0 (00) | 3 (9.7) | 2 (11.1) | 5 |
| | No | 19 (100) | 16 (90.3) | 16 (88.9) | |
| Limited ROM | Yes | 0 (00) | 9 (47.4) | 6 (33.3) | 15 |
| | No | 19 (100) | 10 (52.6) | 12 (66.7) | |
| Malunion | Yes | 0 (00) | 9 (47.4) | 7 (41.2) | 16 |
| | No | 19 (100) | 10 (52.6) | 11 (58.8) | |
| Nonunion | Yes | 0 (00) | 2 (6.5) | 0 (00) | 2 |
| | No | 19 (100) | 17 (93.5) | 18 (100) | |
| Total complication rate | | 4 | 29 | 23 | 56 |

ROM: Range of Motion; LCP: Locking Compression Plate; RIN: Retrograde Intramedullary Nailing.

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was 2.8 ± 1.1 . Three cases with infection (9.7%) were found in this group that was superficial in two cases and deep in the other one. Malunion was recorded in 9 patients (29%) that included valgus in 6 cases and knee varus in 3 cases. Two cases of nonunion (6.5%) were also recorded that were treated with ORIF and bone graft. The mean number of physiotherapy sessions of the patients was 27.2 ± 8.3 .

The outcome of patients who were treated with RIN

RIN was implicated in 18 patients, including 7 (38.9%) males and 11 (61.1%) females with a Mean \pm SD age of 33.6 ± 10 years. The fracture type was C2 in 12 (66.7%) cases and C3 in 6 (33.3%) cases. The mean union period was 18.4 ± 5.1 weeks. Knee pain was found in 8 (44.4%) cases. The mean VAS of these patients was 3.1 ± 1.2 . In two patients (11.1%), superficial surgical site infection was noted, which was completely treated via oral antibiotics. Malunion occurred in 7 (41.2%) cases and included valgus in 4 and varus in 3 cases. The mean ROM of the patients was $98.2 \pm 20.1^\circ$. Limited ROM was detected in 6 patients (33.3%). No case of nonunion was recorded in this group. The mean number of physiotherapy sessions was 54.7 ± 13 . Complications of the three surgical approaches are summarized in Table 2 in detail.

Comparison of the outcome of LCP with RIN

The outcome of patients with C2 and C3 fractures was compared between LCP (14 C2 and 8 C3) and RIN (12 C2 and 6 C3) groups. The number of patients who suffered from severe postoperative pain was not significantly different between the two LCP and RIN groups (6 vs 8,

$P=0.48$). The mean pain level was not significantly different between the two groups, as well ($P=0.56$). Also, the mean ROM, malunion rate, infection rate, nonunion rate, and union period were not significantly different ($P=0.89$, $P=0.64$, $P=0.52$, $P=0.14$, and $P=0.41$, respectively).

4. Discussion

In this study, we evaluated the radiological and functional outcome of three popular surgical techniques (screw fixation, LCP, and RIN) in the management of distal femur intra-articular fractures. Our analysis illustrated that screw fixation leads to an acceptable outcome and a considerably low complication rate in the treatment of type B fractures. LCP and RIN are mainly used for the treatment of type C fractures and are associated with several complications, including pain, malunion, limited ROM, and infection. The rate of complications was not significantly different between the LCP and RIN groups. Rademakers et al. analyzed the long-term functional and radiological outcome of surgically treated intra-articular fractures of the distal femur in 33 type B and 33 type C distal femoral fractures.

All patients were treated by ORIF. Screw fixation alone was used for type B fractures. LCP was used for type C fractures. At the one-year follow-up, only one case of non-union was detected in their series. Twenty-one patients (31%) had mild pain and seven patients (10%) had moderate pain with weight-bearing. At a mean follow-up of 14 years, the mean knee ROM in their population was 118° (range $10-145^\circ$). The Neer score demonstrated good to excellent results in 84% of their patients. Patients with isolated fractures achieved significantly better functional

scores. A moderate to severe secondary osteoarthritis was recorded in 36% of patients. Deep wound infection occurred in seven patients (10%). All these patients had sustained an open fracture. They concluded that the surgical treatment of femoral fractures shows good long-term results [8]. They did not provide separate information on screw fixation and LCP. However, the overall ROM was comparable with the study by Rademakers et al. and the present study. The infection rate of the study by Rademakers et al. was higher than the present study, which could be attributed to the higher frequency of open fractures in their studies. The nonunion rate was similar between the two studies. The number of patients who had postoperative pain was more in their study that could be attributed to the different characteristics of patients, such as the presence of multiple fractures.

The short follow-up period of the current study did not allow the assessment of osteoarthritis development. Hoffmann et al. analyzed the complications and clinical outcomes of LCP in the treatment of 111 distal femoral fractures, including types A (44 patients), B (4 patients), and C (63 patients). Among their patients, nonunion occurred in 20 cases (18%) and eleven (9.9%) cases of hardware failure were noted. Mild, moderate, and severe pain was reported in 37%, 10.8%, and 1.8% of patients, respectively. Seventeen patients (15.3%) had an extension limitation of 5° or more. Flexion limitation was seen in 24.3% of patients. Reduced flexion was more in older patients. They concluded that despite modern fixation techniques, distal femoral fractures generally result in persistent disability and unfavorable clinical outcomes [9].

Contrary to the study by Hoffmann et al., we did not treat any type A fracture with LCP. However, the complication rates of our LCP series were considerably lower. This could be attributed to the difference in the age bracket of the patients of the two studies. The mean age of the patients was 36.7 years in the present study and 54 years in the study by Hoffmann et al. Kiran Kumar et al. evaluated the functional outcome, fracture healing, and the complications of distal femoral intra-articular fractures using LCP in 46 patients. The mean age of the patients was 35 years. More than half of their cases had type C3 fractures. At a mean follow-up of 25 months, nonunion was detected only in two cases. ROM of 70-90° was recorded in two cases, while the remaining patients had a ROM of more than 90°. Good/excellent outcome was achieved in 86% of patients. No case of infection or malalignment was noted. They concluded that using the LCP technique leads to a higher union rate when used for the treatment of distal femoral intra-articular fractures [10].

Several other studies have also reported the outcome of LCP in the treatment of distal femoral intra-articular fractures [11-16]. It should be noted that the conflicting results of the different investigations are attributed to the different characteristics of the patients, such as age, fracture type, concurrent fractures, etc. The comparison of studies with different patients' characteristics is not very informative and could only provide an overall insight. The outcome of the RIN technique in the treatment of intra-articular fracture of the distal femur has also been reported in many studies [17-20]. Wang et al. performed a meta-analysis to compare the postoperative complications of RIN and plating for the treatment of distal femoral fractures. Their pooled analysis revealed no significant difference in the rate of infection, nonunion, malunion, delayed union, metalwork failure, knee ROM, and knee pain. They concluded that none of the implants is superior to others in the management of distal femur fractures [21]. Similar to the study by Wang et al., we did not observe any significant difference between the complication rate of the RIN and LCP groups.

Our study had several limitations. The retrospective nature of the study was the main limitation of the study. Besides, the patients were not categorized based on the mechanism of fracture. This study was retrospective research and the sample size was small; thus, we could not randomly assign patients to either group regardless of the stages and this can affect the reliance of our findings. Basically, high-energy trauma cause type C fractures that have been mainly treated either by RIN or LCP, while low-energy trauma mainly results in type B fractures, which were mostly treated by screw followed by LCP. Finally, the follow-up period of this study was not long enough to evaluate the development of secondary osteoarthritis, which is one of the main complications of distal femoral fractures. Thus, further studies with a longer follow-up period are required to confirm our findings.

5. Conclusion

The results of the present study revealed that screw fixation alone could be regarded as a satisfactory technique for the treatment of distal femur intra-articular fractures of type B. However, we cannot compare it with LCP and RIN because screws are used in simple type fracture; thus, logically, the result should be favorable. RIN and plate are used in complex fracture and the result is not as satisfactory as seen in simple fracture type. LCP and RIN are associated with several complications in the treatment of distal femur intra-articular fractures of type C, including nonunion, malunion, pain, infection, and limited ROM. The complication rate was not

significantly different between the RIN and LCP groups. Therefore, both techniques could be equally used for the treatment of type C fractures.

Ethical Considerations

Compliance with ethical guidelines

This research was approved by the institutional review-board of Iran University of Medical Sciences (IR.IUMS. FMD.REC.1398.005). Also, and informed written consent was obtained from all patients.

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Authors' contributions

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Conflict of interest

The authors declared no conflict of interest.

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