International Journal of Medical Toxicology & Legal Medicine Volume 27, No. 1s, 2024
e-ISSN: 0974-4614
p-ISSN: 0972-0448

# Assessment of Outcomes Following Distal Femoral Fractures Treated with Locking Compression Plate Fixation

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Received: 12.05.2024 Revised: 10.06.2024 Accepted: 23.07.2024

**Abstract**
**Introduction:** Fractures of the distal femur are relatively rare but pose significant challenges due to their complex nature. High-speed road accidents are a common cause in younger individuals, while falls at home often lead to these fractures in the elderly, especially in osteoporotic populations. Locking Compression Plates (LCPs) offer advantages in providing stability and promoting successful outcomes in treating these fractures. The goal of the current research is to examine the functional and radiological outcomes of Open Reduction and Internal Fixation (ORIF) of distal femur fractures utilizing a distal femur locking plate.
**Materials and Methods:** This prospective research has been done at Saveetha Medical College and Hospital in Chennai from March 2022 to March 2023 including 30 skeletally mature patients having distal femur fractures. Patients who had fractures in the ipsilateral limb other than the distal femur or open-grade distal femur fractures were not included.A distal femur-LCP was used for fixation after fractures were manually reduced under direct observation. Postoperatively, patients underwent rehabilitation and follow-ups at regular intervals.
**Results:** The study included 30 patients with fractures to the distal femur, with a mean age of 40.3 years and a distribution of fractures resulting from various causes. All patients achieved full weight-bearing postoperatively, with 14.8 weeks being the average period to union. The average postoperative knee flexion was 107.7°, with excellent or good outcomes observed in the majority of cases. Complications included early superficial infections and one case of varus malunion and limb length discrepancy, which required revision surgery.
**Conclusion:** Managing distal femur fractures by utilizing a distal femur locking plate yields favorable outcomes, especially in Type A and C fractures and cases involving osteoporosis and peri-prosthetic fractures. While challenges exist, adherence to fundamental principles of fracture fixation and precise positioning of the implant can lead to satisfactory results. Continued research and refinement of surgical techniques are essential for optimizing outcomes in treating fractures to the distal femur.

**Keywords:** Distal femur fracture,locking compression plate, varus malunion,limb length discrepancy

## Introduction

Distal femur fractures represent just 0.4 percent of all fractures and constitute 4–6% of all femur fractures. High-speed road traffic accidents are a general cause of distal femur fractures, often found in younger and middle-aged individuals. Conversely, low-energy mechanisms like falls at home can lead to distal femur fractures in older people, particularly among osteoporotic populations, specifically women. Treating fractures in the distal femur presents significant challenges due to the complexities involved. The most frequent causes of pain, limited ROM ("Range of Motion"), as well as impaired knee joint function, are articular incongruity and incorrect articular fragment fixation in these types of fractures [2].

In the past, the preferred approach for treating these fractures tended towards conservative methods, such as traction, casting, or a combination thereof. However, conservative management poses challenges, including limitations in achieving reduction and difficulties in maintaining it. Additionally, prolonged immobilization can lead to associated complications, and there are economic considerations due to longer hospital stays, which further restrict the efficacy of conservative approaches.[3,4]

As orthopedic surgery has progressed, the prevailing approach to treating supracondylar and intercondylar femoral fractures has shifted towards operative intervention[5]. These fractures have been treated with a wide range of internal "fixation devices, such as the retrograde supracondylar interlocking nail, dynamic condylar screw plate,condylar buttress plate, and 95-angled blade plate. The risk of unstable fixation is a significant concern, making the use of LCPs advantageous in these patients. LCPs offer the combined benefits of compression plating, bridge plating, and locked plating, enhancing stability and promoting successful outcomes. This study aims to examine the functional as well as radiological outcomes of distal femoral fractures in skeletally mature patients who had ORIF using a distal femur" locking plate.[6]

**Materials and methods**

The current research was done at Saveetha Medical College and Hospital, Chennai from March 2022-2023, involving 30 patients who were followed up for 1 year. The research was authorized by the Institutional Ethics Committee, and agreement was acquired from all participating patients. The research examined thirty skeletally mature patients having distal femur fractures, while those who have distal femur fractures of open grade (specifically, Gustillo-Anderson type 3B and 3C) were excluded. Patients who have experienced a fracture in any other ipsilateral limb than the distal femur are not eligible to take part in this study. In the emergency room, the patients received initial resuscitation, the afflicted leg was splinted, and the CT scans and required radiographs were performed. Intravenous (IV) antibiotics, such as 2nd generation Cephalosporins and Gentamicin, were administered upon admission for open fractures and continued post-operatively as needed. In addition, IV Metronidazole has been administered in situations with open fractures when anaerobic contamination was suspected. A preoperative routine surgical profile was done and anaesthetia fitness for surgery was obtained.

The standard lateral approach was opted for closed distal femur fractures. It required forming a plane that separated "the lateral intermuscular septum from the vastus lateralis muscle. A standard procedure was followed and the incision was made to accommodate the pre-existing" lesion in cases of open fractures to make debridement easier. Using the Swash-Buckler technique or its variants, a lateral parapatellar arthrotomy was carried out to treat articular involvement of the intercondylar notch or the lateral femoral condyle. A medial subvastus incision was also performed in addition to the standard lateral surgery for articular or Hoffa's fracture of the medial femoral condyle.

Fractures were manually decreased while being observed directly with the aid of manual traction. A knee roll was helpful to acquire and sustain the decrease. Using image intensification, the length of the plate and its axial and rotational alignment were confirmed. Temporary fixation was accomplished by employing Kirschner wires. A distal femur locking condylar plate has been utilized for fixation of the fracture, employing locking screws with a diameter of 4.5mm, along with partially-threaded cancellous screws also measuring 4.5mm in diameter. Additionally, Herbert screws were employed for smaller articular fragments, while 6.5mm screws were used for achieving condyles articular reduction. In closed cases, primary bone grafting was performed as and when deemed necessary by the operating surgeon.

A drain was removed post-operatively 48 hrs after surgery and dressing was done regularly on post-op day 2,5.Patients with closed fractures received 2 doses of IV antibiotics while antibiotics were continued for 72 hours in cases of open fractures. Knee bending exercises commenced on the third day following surgery. Active as well as assisted knee ROM exercises have been begun on the same day. Patient mobilization was examined on the basis of factors like bone quality, injury severity, and fracture pattern. Typically, patients began using crutches or a walker for mobility from around the fifth to sixth post-operative day, continuing until about six weeks post-surgery. Usually, full weight-bearing ambulation without assistance started around three months later for most cases showing radiographic evidence of fracture union. On the twelfth postoperative day, the patients were released after having their sutures removed. Subsequent follow-up appointments occurred at six weeks, three months, 6 months, and 1 year intervals. The functional outcome has been evaluated using Neer's functional Score at the end of one year. The computer-based statistical analysis software was applied to perform the statistical data analysis, SPSS version 20 (IBM, Chicago, USA). Paired t-tests were employed when comparing 2 correlated groups, whereas independent t-tests were used for uncorrelated groups. For every analysis, a p-value <0.05 was deemed statistically significant.

**Results**

The study included 30 individualswith distal femur fractures fixed internally with LCPs. Their ages ranged from 24 to 58 years, averaging 40.3 years [Figure 1].Among them, seventeen were male and thirteen were female [Figure 2].Fractures resulted from motor vehicle accidents in sixteen cases, slips, and falls in eleven cases, and falls from height in three cases [Table 1].Fourteen fractures were on the right side, whereas sixteen occurred on the left. The average hospital stay duration was 15.2days, ranging between 8-32 days. The duration between the injury and surgery was observed to be 4.4 days on average, ranging from 1 to 12 days. The average duration of patient follow-up was 8.2 monthswith a range of 6 -12 months.

Based on the AO classification system, there were 3 fractures categorized as Type A1, ten as Type A2, one as Type A3, three "as Type B1, four as Type B2, one as Type B3, six as Type C1, one as Type C2, and one as Type C3 [Table 2]. All patients were capable of bearing full weight postoperatively. The average time to union was 14.8 weeks, ranging between 12 to 24 weeks. In" our study, patients had a mean post-op knee flexion of 107.7°, ranging from 70° to 110° [Table 3].

Neer's criteria, which encompassed assessments related to pain, motion range, work capacity and walking, anatomy, and X-ray findings, were used to calculate the score at 1 year. In total, outcomes have been deemed excellent in 11 cases (37%), good in 18 cases (60 %), and fair in one case (3 %).The overall average knee score in our study was 84.4 % [Figure 3].

In our investigation, two patients encountered early post-operative complications characterized by superficial infections. After treating these individuals with parenteral antibiotics that were sensitive to culture in addition to an antiseptic dressing, the fractures were eventually sufficiently healed. One patient presented with varus malunion and limb length discrepancy of 2 cm, and was taken up for revision surgery using the Ilizarov technique.One patient presented with a broken plate in the condylar region one month after surgery and developed pain.He underwent a secondary operation, after which he exhibited a good functional outcome.

**Discussion**

Fracture patterns nowadays tend to lean towards the complex comminuted types, largely influenced by the abundance of higher-speed vehicles. The LCP is structured as a single beam, with its fixation strength determined by the combined effect of all screw-bone interfaces instead of relying on the individual axial stiffness and pullout resistance of a single screw in unlocked plates[7]. Its distinctive biomechanical role focuses on splinting instead of compression, leading to flexible stabilization, stress shielding prevention, and stimulation of callus formation[8]. When employed through a minimally invasive approach, it facilitates rapid healing, decreases infection rates, and minimizes resorption of the bone by preserving the supply of blood. The plate's "combi hole" has two advantages: In fractures where usual screw purchase is hindered, standard screws can be utilized in compression mode to secure screws. This capability of locked fixation, coupled with angular stability, contributes to preserving the periosteal supply of blood. Additionally, the advantage of not requiring plate contouring as well as minimizing "toggle at the screw-plate interface enhances the implant's holding power [9].

A construct's rigidity influences how the biomechanical environment is constructed and impacts fracture healing. Despite some developments in technology like the use of far cortical locking to minimize stiffness of constructs, there is a paucity of information to guide surgeons on modulating construct stiffness with currently available implants. Our study showed that increased length of plates would result in greater rigidity when plating material, screw number and type, and fracture" working distance are held constant. This agrees with Riicci et al who found short plate length as an independent risk factor for non-union[10]. In contrast, shorter plates probably reduce the fracture working distance while longer plates enhance union rates by spanning across larger areas of comminution thereby reducing stiffness. Our findings indicate that for similar conditions, an increase in the plate length increased total construct stiffness.

In the research, the average age was 40.3 years, and favorable outcomes were observed across a spectrum of age groups, encompassing both older and younger patients.In all cases, stainless steel was used as the material for the implant, and successful union was achieved with a substantial formation of callus. The union average duration in all our cases varied between 12-24 weeks, with open fractures requiring a longer time to unite compared to closed fractures. Specifically, the mean duration for union rose to 18–24 weeks in cases of open fractures, indicating that open fractures may be associated with a delayed union. This is concerning because studies by Ricci et al. also indicate that open fractures increase the chance of a prolonged union.[11] Additionally, they highlighted smoking, diabetes, and elevated BMI as independent risk factors influencing fracture union, factors that are beyond the control of the surgeon.

In our series,one case was rated as fair.The patient had a limb length discrepancy of 2cm. Previous research has indicated that fractures classified as type A1 and C1 generally exhibit more favorable outcomes[12].

Fixing distal femoral fractures with locking plates is still a complicated procedure, and most implant failures are related to poor surgical skills as compared to implant faults. One of the cases in our study had varus malunion, and the patient had broken implants. This was probably because the patient had started weight-bearing too soon and had not followed our physiotherapy instructions. Failure causes were found in a retrospective analysis done byToro et al. between 2011&2014, and they included insufficient fracture bridging, insufficient plate length, and insufficient locking screws for fracture fixing[13]. They found that there is little literature now accessible and that locking plates are still a developing method.[14-18]

**Conclusion**

Utilizing a distal femur locking plate remains a promising approach for managing distal femur fractures. However, achieving precise positioning and fixation is crucial to ensure favorable outcomes. We advocate for the application of this implant in Type A & C fractures, as well as in cases involving osteoporosis and peri-prosthetic fractures. Through conducting this study, we aim to assert with a certain level of confidence that distal femur fractures, encompassing extra-articular, intra-articular, and partial articular non-comminuted and comminuted variations, can yield satisfactory results when appropriately fixed, adhering to fundamental principles of fracture fixation. For these types of fractures, the primary implant that is used could be a distal femur locking plate.

**Declarations:**
"Funding: None
Conflict of Interest: None
Ethical Approval: Not required"

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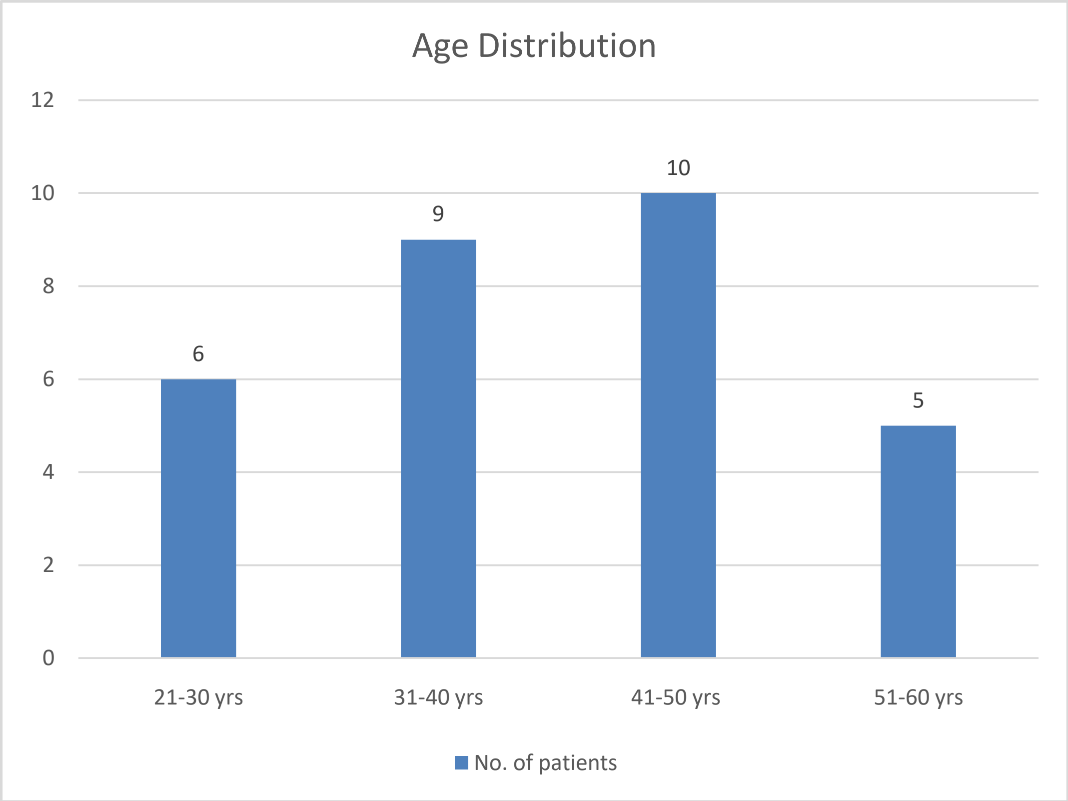


**Figure 1 :** Age distribution

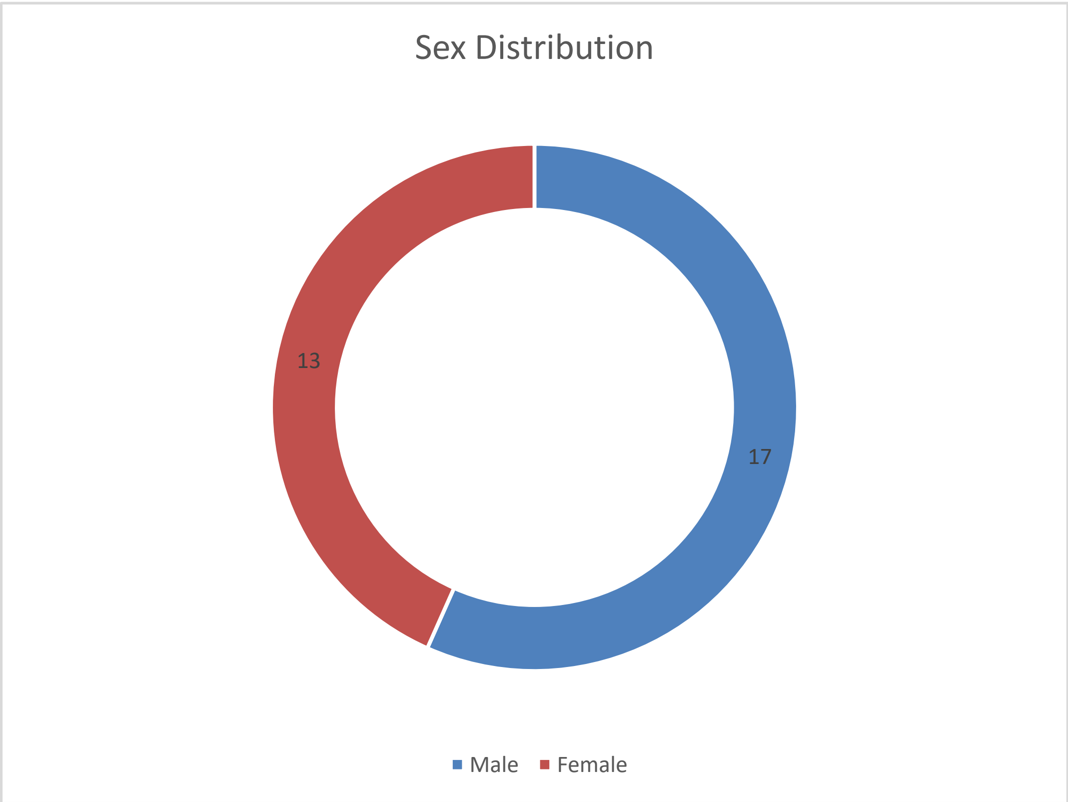


**Figure 2 :** Distribution of gender among participants

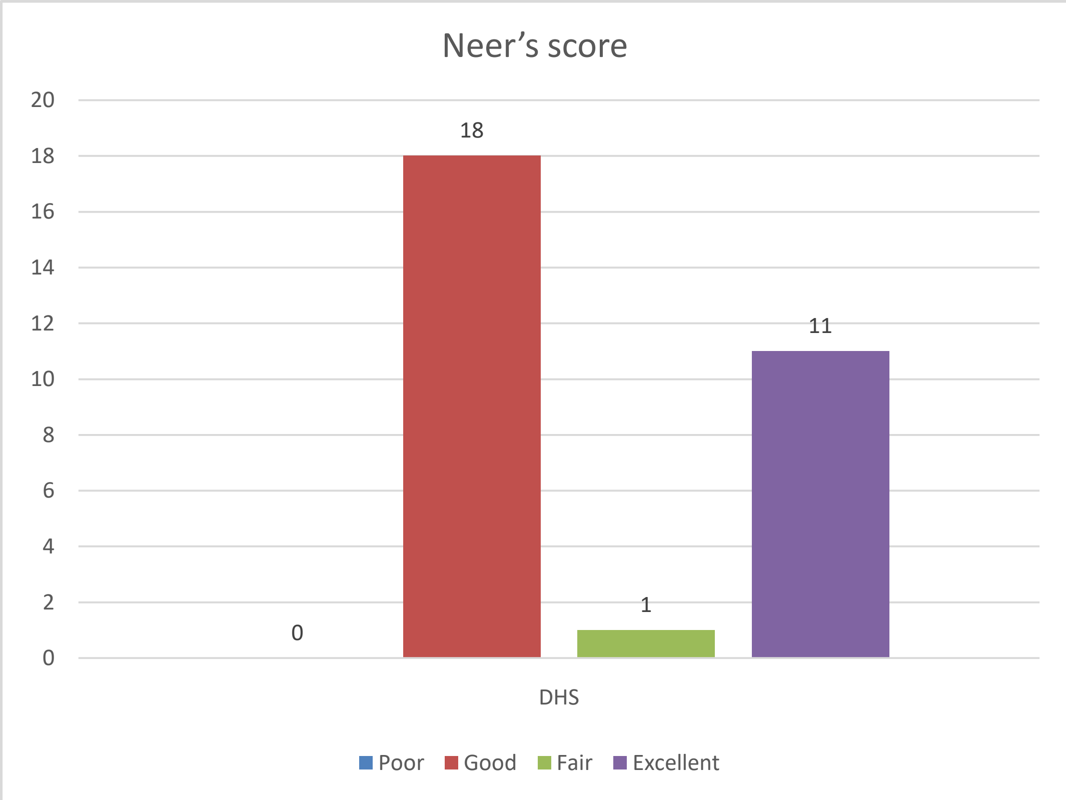


**Figure 3 :** Functional outcome using Neer's score

**Table 1 :** Mode of injury

| Mode of Injury | No. of patients | Percentage |
|---|---|---|
| RTA | 16 | 53.3 % |
| Slip and Fall | 11 | 36.6 % |
| Fall from height | 3 | 10 % |

**Table 2 :** AO fracture classification

| AO type | No. of patients |
|---|---|
| Type A1 | 3 |
| Type A2 | 10 |
| Type A3 | 1 |
| Type B1 | 3 |
| Type B2 | 4 |
| Type B3 | 1 |
| Type C1 | 6 |
| Type C2 | 1 |
| Type C3 | 1 |

**Table 3 :** Patient Demographics and data

| Master chart | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **S. No** | **Age** | **Sex** | **Side** | **Mode of injury** | **AO classification Type** | **Surgery injury interval (in days)** | **Procedure** | **Radiological union (in weeks)** | **Complication** | **Knee flexion ( in degrees ) - Post op** | **Neer's score ( 0-100 ) at 1 year** | **Outcome** | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1** | 24 | M | R | RTA | A2 | 8 | ORIF with LCP | 16 | Nil | 110 | 88 | Excellent | |
| **2** | 26 | M | L | RTA | C3 | 1 | ORIF with LCP , debridement | 24 | Nil | 90 | 80 | Good | |
| **3** | 42 | F | L | SAF | B1 | 6 | ORIF with LCP | 14 | Nil | 100 | 90 | Excellent | |
| **4** | 32 | M | L | RTA | C1 | 6 | ORIF with LCP | 16 | Nil | 100 | 84 | Good | |
| **5** | 36 | M | R | FFH | C1 | 5 | ORIF with LCP | 14 | Nil | 110 | 84 | Good | |
| **6** | 54 | M | L | RTA | C1 | 2 | ORIF with LCP | 14 | Nil | 100 | 90 | Excellent | |
| **7** | 32 | M | L | RTA | A2 | 3 | ORIF with LCP | 16 | Nil | 110 | 82 | Good | |
| **8** | 48 | F | R | SAF | B2 | 1 | ORIF with LCP | 12 | Nil | 110 | 92 | Excellent | |
| **9** | 44 | F | L | SAF | B3 | 10 | ORIF with LCP | 16 | Nil | 100 | 82 | Good | |
| **10** | 40 | M | R | FFH | C1 | 2 | ORIF with LCP | 18 | Nil | 100 | 78 | Good | |
| **11** | 28 | M | R | RTA | A2 | 2 | ORIF with LCP | 14 | Plate breakage, varus malunion | 90 | 72 | Good | |
| **12** | 45 | F | L | SAF | A1 | 4 | ORIF with LCP | 12 | Nil | 100 | 92 | Excellent | |
| **13** | 42 | F | L | RTA | A2 | 1 | ORIF with LCP | 16 | Nil | 110 | 82 | Good | |
| **14** | 38 | F | R | RTA | A2 | 12 | ORIF with LCP | 16 | Nil | 90 | 84 | Good | |
| **15** | 56 | M | L | SAF | B1 | 2 | ORIF with LCP | 12 | Nil | 100 | 94 | Excellent | |
| **16** | 26 | M | R | SAF | B2 | 4 | ORIF with LCP | 14 | Nil | 100 | 80 | Good | |
| **17** | 58 | F | R | SAF | A1 | 2 | ORIF with LCP | 12 | Nil | 90 | 84 | Good | |
| **18** | 28 | M | R | FFH | A2 | 1 | ORIF with LCP | 12 | Nil | 100 | 92 | Excellent | |
| **19** | 44 | F | L | RTA | A3 | 5 | ORIF with | 18 | Shortening ( 2 cm ) | 70 | 68 | Fair | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | LCP , debridement | | | | | | |
| **20** | 52 | F | R | SAF | B2 | 7 | ORIF with LCP | 14 | Nil | 90 | 90 | Excellent | |
| **21** | 36 | M | L | RTA | C2 | 5 | ORIF with LCP , debridement | 18 | Nil | 90 | 84 | Good | |
| **22** | 30 | M | R | RTA | A2 | 3 | ORIF with LCP | 12 | Nil | 100 | 88 | Excellent | |
| **23** | 38 | F | L | SAF | B1 | 12 | ORIF with LCP | 14 | Nil | 90 | 82 | Good | |
| **24** | 32 | M | L | RTA | A2 | 1 | ORIF with LCP | 14 | Superficial wound infection | 90 | 84 | Good | |
| **25** | 46 | M | R | RTA | A2 | 2 | ORIF with LCP | 16 | Nil | 100 | 82 | Good | |
| **26** | 50 | F | R | RTA | C1 | 6 | ORIF with LCP | 18 | Nil | 110 | 82 | Good | |
| **27** | 48 | M | L | RTA | C1 | 4 | ORIF with LCP | 16 | Nil | 110 | 84 | Good | |
| **28** | 54 | F | R | SAF | B2 | 10 | ORIF with LCP | 12 | Nil | 100 | 88 | Excellent | |
| **29** | 34 | M | L | RTA | A2 | 3 | ORIF with LCP | 12 | Nil | 110 | 86 | Excellent | |
| **30** | 48 | F | L | SAF | A1 | 2 | ORIF with LCP | 14 | Nil | 100 | 84 | Good | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |