



Functional and Radiological Outcomes of Proximal Tibial Fractures Managed at a Tertiary Care Center: A Prospective Observational Study

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Abstract

Background: Proximal tibial fractures are complex injuries that require precise evaluation and appropriate fixation to restore knee function and prevent long-term disability. This study was conducted to assess functional outcomes, radiological union, and complications in patients with proximal tibial fractures managed at a tertiary care center. **Methods:** This prospective observational study included 50 patients with proximal tibial fractures classified using the Schatzker system. Patients were treated with ORIF, MIPPO, or conservative methods. Follow-up was conducted at 6 weeks, 12 weeks, and 6 months. Radiological union was assessed using serial radiographs, and functional outcome was evaluated using the Modified Rasmussen scoring system. **Results:** Most patients were males (80%) aged 31–50 years, with road traffic accidents as the commonest cause (76%). Surgical treatment was performed in 94% of cases. Radiological union was achieved in 98% of patients. Functional outcomes were excellent in 58%, good in 28%, and fair in 14%, with no poor outcomes. Complications occurred in 8% of patients. **Conclusion:** Surgical management of proximal tibial fractures using locking plates provides high union rates, good functional outcomes, and low complication rates when combined with appropriate surgical timing and early mobilization.

Keywords: Functional outcome; Locking compression plate; Proximal tibial fracture; Schatzker classification; Tibial plateau



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INTRODUCTION

Proximal tibial fractures account for approximately 1% of all fractures and significantly affect knee function and mobility (1). Involvement of the tibial plateau, a key weight-bearing surface, can lead to long-term disability if inadequately treated. In India, the incidence has increased due to high-velocity road traffic accidents and falls, predominantly affecting males aged 20–50 years. Road traffic accidents account for 70–85% of cases, reflecting occupational and vehicular exposure and resulting in substantial socioeconomic burden (2).

The Schatzker classification is the most widely used system for proximal tibial fractures, classifying them into six types based on injury pattern (3). Types I–III result from low-energy trauma, while Types IV–VI represent high-energy injuries with comminution; bicondylar fractures (Types V and VI) account for 30–40% of cases

in India (4). Management has evolved toward operative fixation focused on anatomical reduction and early mobilization. Open reduction and internal fixation with locking compression plates is preferred for displaced fractures, with Indian studies reporting excellent and good outcomes in 52% and 34% of cases using the Modified Rasmussen score (5,6). Locking plate fixation yields favorable functional outcomes, with a mean knee flexion of 113° at six months (6). Minimally invasive percutaneous plate osteosynthesis (MIPPO) further improves results in complex Schatzker Type IV–VI fractures, achieving excellent outcomes in 63.3% of cases with minimal soft-tissue complications by preserving periosteal blood supply (7). The three-column concept of the tibial plateau has enhanced surgical planning in complex bicondylar fractures and is associated with a 90% return to pre-injury activity levels

when all columns are adequately stabilized (8). Functional outcomes are commonly assessed using validated scores such as the Modified Rasmussen, Knee Society, and IKDC scores (9), with reported improvement in IKDC scores from 80.2% at three months to 86.92% at six months, highlighting the importance of anatomical reduction and early mobilization (10).

Despite advances in surgical techniques and implant technology, postoperative complications such as infection (3–10%), knee stiffness (10–20%), malunion (5–15%), and post-traumatic osteoarthritis (20–30%) remain concerns at long-term follow-up (11). Careful surgical technique and structured rehabilitation are essential to reduce these complications. The present study aims to evaluate the functional outcomes of proximal tibial fractures treated at the tertiary care center, LG Hospital, Maninagar, Ahmedabad.

MATERIALS AND METHODS

Study Design and Setting: This prospective observational study was conducted at a tertiary care teaching hospital, LG Hospital, Maninagar, Ahmedabad from May 2022 to June 2024. The study protocol was approved by the Institutional Ethics Committee, and written informed consent was obtained from all participants or their legal guardians prior to enrollment.

Study Population and Sample Size: A total of 50 patients with radiologically confirmed proximal tibial fractures were enrolled in the study. The sample included both intra-articular and extra-articular fractures managed surgically. Patients were recruited consecutively from the emergency department and orthopedic outpatient clinic.

Inclusion Criteria: Patients aged ≥ 18 years with closed or Gustilo-Anderson Grade I and II open proximal tibial fractures were included. Both unilateral and bilateral fractures were eligible. All Schatzker classification types (I–VI) and extra-articular proximal tibial fractures were considered for enrollment.

Exclusion Criteria: Patients with pathological fractures, severe compound injuries (Gustilo-Anderson Grade III), neurovascular compromise, compartment syndrome, ipsilateral limb fractures, pre-existing knee arthritis, and those medically unfit for surgery were excluded from the study.

Diagnostic Evaluation: Initial assessment followed Advanced Trauma Life Support (ATLS) protocols. Anteroposterior and lateral radiographs of the knee joint were obtained for all patients. Computed tomography (CT) with three-dimensional reconstruction was performed in cases of complex intra-articular fractures to better delineate fracture patterns and aid surgical planning. Fractures were classified according to the Schatzker classification system based on radiographic and CT findings (3).

Treatment Protocol: All patients received initial stabilization with above-knee splints or skeletal traction. Soft tissue status was assessed, and surgery was delayed until wrinkle sign appeared (typically 5–10 days) in cases with significant swelling or fracture blisters. The treatment modality was selected based on fracture type, displacement, articular depression, and soft tissue condition.

Treatment Modalities:

- **Conservative Management:** Conservative treatment was reserved for minimally displaced fractures, medically unfit patients, or those with stable extra-articular fractures. Patients were treated with above-knee plaster cast immobilization for approximately six weeks. Radiographs were taken periodically to assess fracture alignment and healing. Gradual knee mobilization and progressive weight bearing were initiated once signs of radiological union appeared.
- **Closed Reduction and Percutaneous Cancellous Screw Fixation:** This method was used in selected cases with split or minimally depressed fractures that could be reduced closed. Reduction was achieved under fluoroscopic guidance using ligamentotaxis. Percutaneous cancellous screws were inserted to maintain reduction. This technique preserves soft tissue integrity and minimizes surgical trauma.
- **Open Reduction and Internal Fixation (ORIF):** ORIF was the most commonly employed modality. It was indicated for displaced intra-articular fractures, bicondylar fractures, fractures with articular depression, and unstable patterns. Fixation was done using buttress plates or locking compression plates depending on fracture configuration. Bone grafts or substitutes were used where metaphyseal voids were present. ORIF allows anatomical reduction of the articular surface and restoration of mechanical alignment.
- **Minimally Invasive Percutaneous Plate Osteosynthesis (MIPPO):** MIPPO was used in fractures with metaphyseal comminution and minimal articular displacement. Plates were inserted submuscularly through small incisions,

minimizing periosteal stripping and preserving fracture biology. Locking plates provided angular stability and facilitated early mobilization.

- **Temporary External Fixation:** In patients with severe soft tissue compromise or excessive swelling, temporary external fixation was applied as a damage-control procedure. Definitive fixation was performed after soft tissue recovery, usually after 7–10 days.

Surgical technique: All procedures were performed under spinal or general anesthesia depending on patient condition. Patients were positioned supine on a radiolucent table. A pneumatic tourniquet was applied whenever required. The surgical approach was selected based on the fracture pattern. An anterolateral approach was used for lateral column fractures, a posteromedial approach for posteromedial column fractures, and combined approaches were employed for bicondylar fractures. A minimally invasive anterolateral approach was utilized for fractures managed with MIPPO.

- **Reduction Technique:** Fracture reduction was achieved using ligamentotaxis, manual manipulation, and fluoroscopic guidance. Depressed articular fragments were elevated using bone punches or elevators. Temporary fixation was achieved using Kirschner wires.
- **Fixation:** Locking compression plates (3.5 mm or 4.5 mm) were applied according to fracture pattern. Cortical screws were used for shaft fixation, while locking screws were used proximally. Bone grafts or substitutes were added when metaphyseal voids were present.
- **Closure and Postoperative Care:** Wounds were closed in layers over suction drains when required. Postoperative immobilization was provided using an above-knee slab or brace. Early quadriceps exercises and knee mobilization were initiated. Progressive weight bearing was allowed based on radiological evidence of healing. Functional outcome was assessed using the Modified Rasmussen clinical scoring system, which evaluates pain, walking capacity, range of motion, extension lag, and joint stability (9). Scores were categorized as excellent (28-30 points), good (24-27 points), fair (20-23 points), or poor (<20 points).

Data Collection and Statistical Analysis: Demographic data, injury characteristics, fracture patterns, treatment details, radiological union times, complications, and functional outcomes were recorded on standardized case record forms. Data were entered into Microsoft Excel and analyzed using descriptive statistics. Continuous variables were expressed as means and ranges, while categorical variables were presented as frequencies and percentages.

Table 1: Demographic Profile of Patients

Parameter	Number (n)	Percentage (%)
Age (Years)		
18–20	3	6
21–30	10	20
31–40	12	24
41–50	12	24
51–60	8	16
>60	5	10
Gender		
Male	40	80
Female	10	20

Table 1 depicts the demographic characteristics of the study population. The majority of patients were in the 31–40 years and 41–50 years age groups, each accounting for 12 patients (24%). This was followed by the 21–30 years age group comprising 10 patients (20%). Patients aged 51–60 years constituted 8 cases (16%), while those above 60 years accounted for 5 cases (10%). Only 3 patients (6%) were in the 18–20 years age group. The study population showed a marked male predominance, with 40 male patients (80%) and 10 female patients (20%).

Table 2: Injury Characteristics

Parameter	Number (n)	Percentage (%)
Side of Limb Involved		
Right	34	68.0
Left	15	30.0
Bilateral	1	2.0
Mode of Injury		
Road Traffic Accident	38	76.0
Fall	7	14.0
Assault	5	10.0
Type of Fracture		
Open	6	12.0
Closed	44	88.0

Table 2 summarizes the injury characteristics of patients with proximal tibial fractures. The right lower limb was more frequently involved, seen in 34 patients (68%), compared to the left limb in 15 patients (30%). Bilateral involvement was rare and observed in only one patient (2%). Road traffic accidents were the most common mode of injury, accounting for 38 cases (76%), followed by falls in 7 patients (14%) and assault in 5 patients (10%). The majority of fractures were closed, observed in 44 patients (88%), while open fractures constituted 6 cases (12%).

Table 3: Fracture Pattern (Schatzker Classification)

Schatzker Type	Number (n)	Percentage (%)
Type I	8	16.0
Type II	10	20.0
Type III	3	6.0
Type IV	4	8.0
Type V	6	12.0
Type VI	8	16.0
Extra-articular	12	24.0

Table 3 illustrates the distribution of proximal tibial fractures according to the Schatzker classification. Type II fractures were the most common, seen in 10 patients (20%). Type I and Type VI fractures were observed in 8 patients each (16% each). Extra-articular fractures constituted a significant proportion, accounting for 12 cases (24%). Type V fractures were noted in 6 patients (12%), while Type IV and Type III fractures were less common, seen in 4 (8%) and 3 patients (6%), respectively.

Table 4: Treatment Method and Radiological Union

Parameter	Number (n)	Percentage (%)
Method of Treatment		
ORIF	39	78.0
MIPPO	8	16.0
Closed Reduction / Conservative	4	8.0
Time to Radiological Union (Weeks)		
10–15	21	42.0
16–20	28	56.0
>20	1	2.0

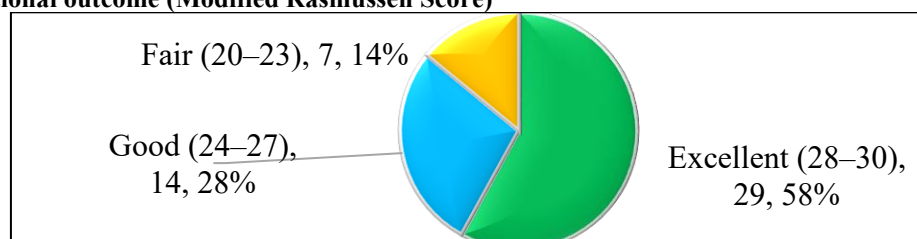
Table 4 presents the treatment modalities employed and the time to radiological union. Open reduction and internal fixation (ORIF) was the most frequently used treatment method, performed in 39 patients (78%). Minimally invasive percutaneous plate osteosynthesis (MIPPO) was used in 8 patients (16%), while 4 patients (8%) were managed conservatively with closed reduction. Radiological union was achieved between 16–20 weeks in the majority of patients, accounting for 28 cases (56%). Union within 10–15 weeks was seen in 21 patients (42%), whereas delayed union beyond 20 weeks occurred in only one patient (2%).

Table 5: Complications and Functional Outcome

Parameter	Number (n)	Percentage (%)
Complications		
Infection	3	6.0
Knee Stiffness	1	2.0
None	46	92.0

Table 5 summarizes the complications encountered and the functional outcomes assessed using the Modified Rasmussen clinical scoring system. Most patients did not experience any complications, accounting for 46 cases (92%). Infection was observed in 3 patients (6%), while knee stiffness was noted in one patient (2%).

Figure 1: Functional outcome (Modified Rasmussen Score)



Functional outcome assessment revealed excellent results in 29 patients (58%) and good results in 14 patients (28%). Fair outcomes were observed in 7 patients (14%), and no patient had a poor outcome

DISCUSSION

The present study evaluated the functional outcomes of 50 patients with proximal tibial fractures treated at a tertiary care center and provides insights into demographic patterns, injury mechanisms, and clinical outcomes consistent with contemporary Indian literature.

Demographic profile: In the present study, A marked male predominance (80%) was observed, with the majority of patients belonging to the 31–50 years age group (48%). This finding is comparable to studies from Karnataka, which reported 84% male patients with a mean age of 38.5 years in bicondylar fractures treated with dual plating (12), and from Ahmedabad, where 86% of patients were male with peak incidence in the 41–50 years age group (6). These trends likely reflect increased occupational and vehicular exposure among males in the productive age group.

Injury characteristics: Road traffic accidents accounted for 76% of injuries, consistent with other Indian studies reporting RTA as the predominant mechanism, particularly in high-energy Schatzker Type V and VI fractures (4). This underscores the growing burden of trauma-related proximal tibial fractures in India, with significant socioeconomic and healthcare implications. In the present study, the right lower limb was more commonly involved (68%), a finding comparable to reports from Kolkata and earlier studies that documented similar laterality patterns (10,13). Although the exact biomechanical reasons remain unclear, this may be related to vehicular dynamics, dominant limb use, or injury mechanisms during road traffic accidents and falls.

Fracture Pattern Distribution: In the present study, Schatzker Type II fractures were the most common intra-articular pattern (20%), followed by Type I fractures (16%). Type V and Type VI fractures accounted for 12% and 16% of cases, respectively, while extra-articular fractures constituted 24% of the study population. This distribution differs from several Indian studies that predominantly included complex fracture patterns. Studies focusing exclusively on Schatzker Types IV–VI report a higher proportion of severe injuries, reflecting referral bias at tertiary care centers (7). Similarly, series concentrating on bicondylar fractures have reported a predominance of Type VI (56.67%) and Type V (43.33%) fractures (14).

Treatment Strategies and Surgical Timing: In the present study, surgical management was employed in 94% of cases, with ORIF performed in 78% and MIPPO in 16% of patients, while only 8% were managed conservatively. This preference for surgical intervention is consistent with current evidence favoring anatomical reduction and

early mobilization in displaced proximal tibial fractures, as reported in recent studies utilizing ORIF and MIPPO with locking compression plates (5,6). The introduction of locking compression plate technology has significantly improved the management of proximal tibial fractures, particularly in complex and osteoporotic cases. Previous studies have demonstrated improved functional outcomes with early mobilization, reporting progressive improvement in knee range of motion from 105.7° at 3 months to 120.6° at 6 months (10). Similar trends in functional recovery were observed in our study during follow-up.

Radiological Union and Healing Patterns: Radiological union was achieved in 98% of patients, with most fractures uniting between 16–20 weeks (56%), while 42% achieved union within 10–15 weeks. These findings are comparable to previous studies reporting mean union times of 13.2 weeks in three-column fixation (8) and 13.75 weeks in bicondylar fractures treated with dual locking plates, with no cases of nonunion (12). Only one patient (2%) demonstrated delayed union, which resolved with prolonged protected weight-bearing without the need for bone grafting or revision surgery. The low rate of healing complications may be attributed to stable fixation provided by modern locking plate systems and preservation of periosteal blood supply through minimally invasive techniques such as MIPPO (7).

Functional Outcomes: Functional assessment using the Modified Rasmussen scoring system showed excellent outcomes in 58% of patients, good in 28%, and fair in 14%, with no poor results, yielding an 86% excellent-to-good rate. These results are comparable with Indian studies reporting 86% combined excellent and good outcomes following fixation with locking plates (6) and similar findings from Bangladesh using the same scoring system (11). Lower excellent outcome rates have been reported in studies focusing exclusively on complex bicondylar fractures, such as Schatzker Type V and VI injuries, where excellent outcomes ranged from 33.33% despite acceptable overall results (15). This highlights the influence of fracture complexity on functional recovery, with simpler fracture patterns achieving better outcomes. The three-column fixation concept has further improved outcomes in complex fractures, with studies reporting up to 90% return to pre-injury activity when all columns are adequately addressed (8), emphasizing the importance of fracture pattern-based surgical planning.

Complications and Challenges: The overall complication rate in the present study was 8%, comprising infection in 6% and knee stiffness in 2% of patients, which compares favorably with existing literature. Previous studies have

reported similar minor complications, predominantly superficial infections managed successfully with antibiotics and wound care, without implant failure or nonunion (12,4). Knee stiffness remains a recognized concern following proximal tibial fractures. The low incidence observed in our study (2%) is considerably lower than the 10–20% reported in the literature, likely reflecting the benefits of early mobilization and stable fixation with locking plate systems (10). Other studies have emphasized aggressive physiotherapy and early range-of-motion exercises, particularly in complex bicondylar fractures, to minimize stiffness (14). Effective infection prevention relies on meticulous surgical technique, appropriate antibiotic prophylaxis, and careful consideration of soft tissue status. Studies

optimizing surgical timing based on soft tissue condition have reported excellent outcomes with no deep infections, underscoring the importance of these strategies (7).

Clinical Implications: Anatomical reduction with stable fixation using locking plates, appropriate surgical timing based on soft tissue status, and early mobilization are key to achieving optimal outcomes in proximal tibial fractures. Complex bicondylar fractures benefit from a three-column-based fixation strategy to ensure comprehensive stabilization. These principles are consistent with current evidence-based recommendations (1,5).

CONCLUSION

Proximal tibial fractures pose a complex management challenge requiring individualized treatment. This study demonstrates that surgical management with locking compression plates using ORIF or MIPPO techniques provides excellent to good functional outcomes in 86% of patients, with high union rates (98%) and minimal complications (8%). Road traffic accidents remain the predominant cause, mainly affecting males in the productive age group. Optimal outcomes depend on appropriate surgical timing, anatomical reduction, stable fixation, and early mobilization. The findings support the safety and effectiveness of modern locked plating techniques. Further multicenter studies with longer follow-up are required to evaluate long-term outcomes and refine fixation strategies for complex fracture patterns.

CLINICAL CASES

CASE 1: 25-Year-Old Male with Road Traffic Accident – Right Side Injury

Figure 1.1 PRE-OP X RAY and CT SCAN

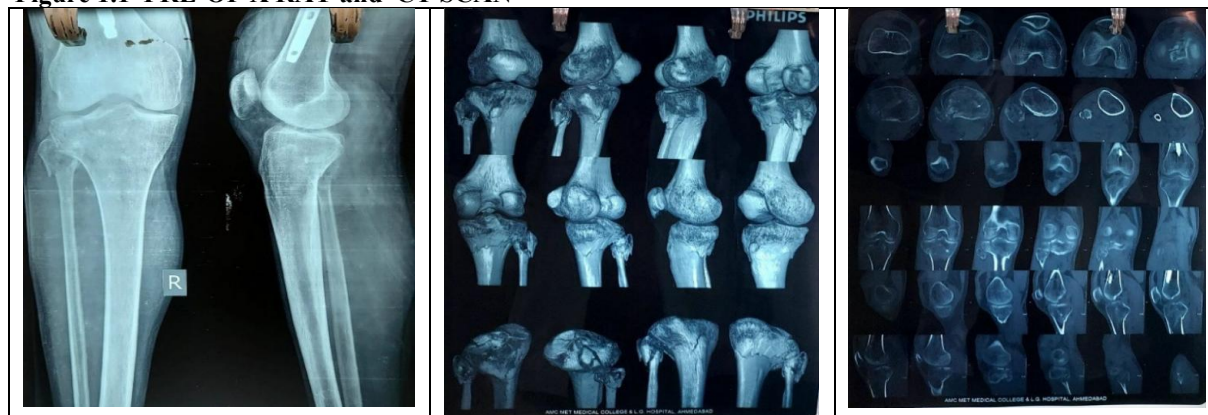
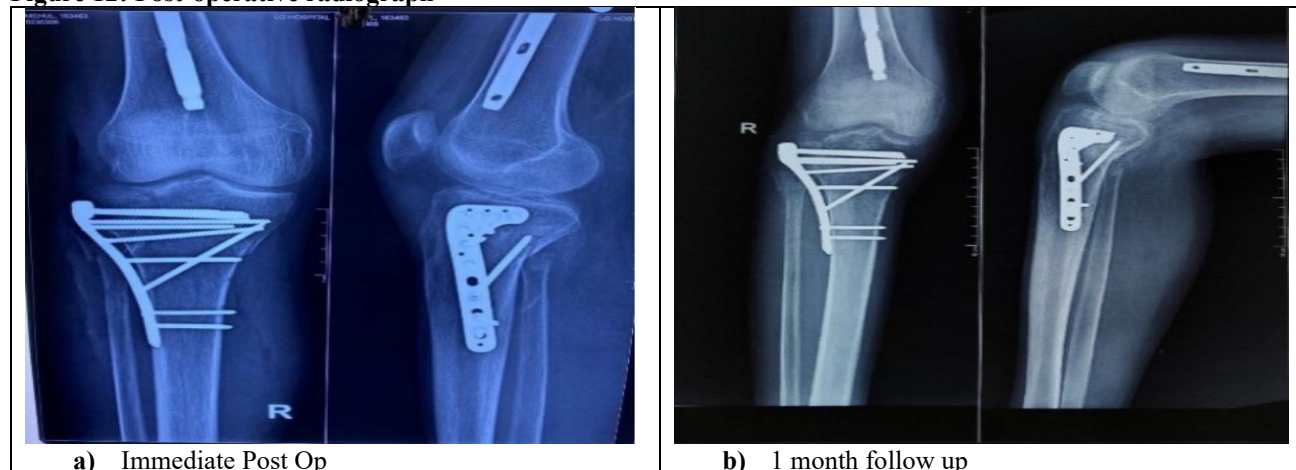
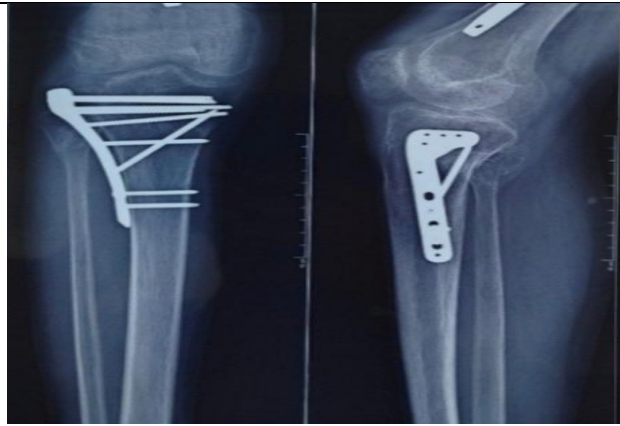


Figure 12: Post-operative radiograph





c) 3 month follow up



d) 6 month follow up



CASE 2: 55-Year-Old Male with Road Traffic Accident – Bilateral Injury

Figure 2.1: Pre-operative X-ray (bilateral involvement)



Figure 2.2: Pre-operative CT scan

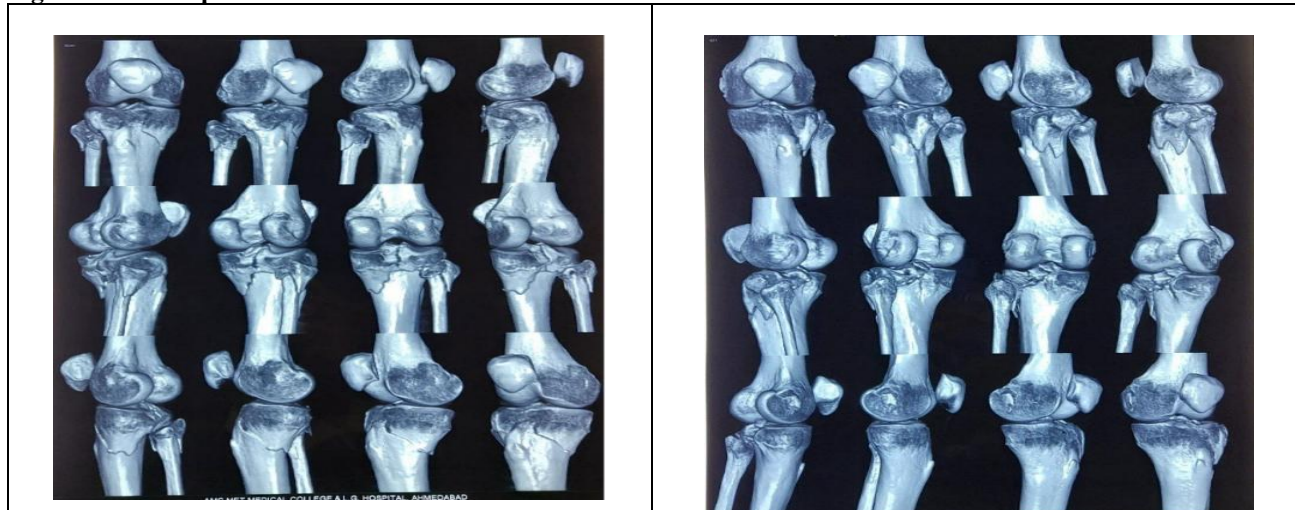
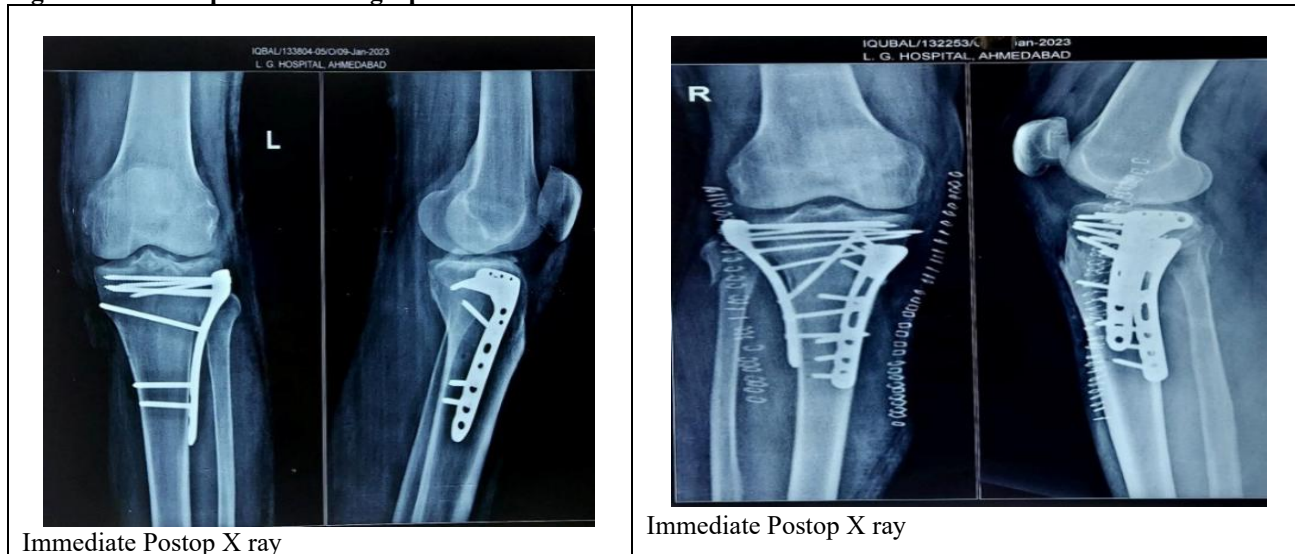
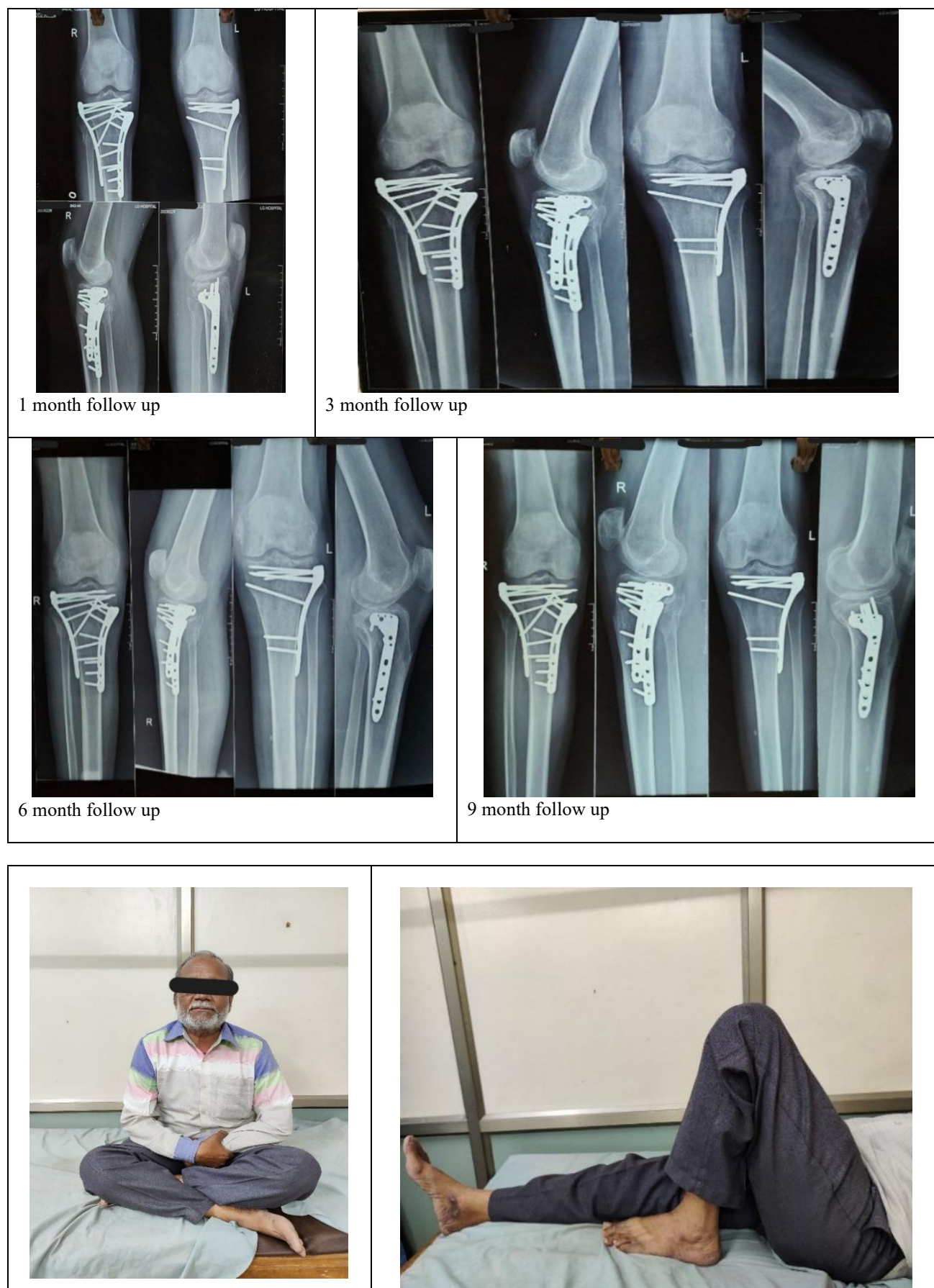


Figure 2.2: Post-operative radiograph







CASE 3: 37-Year-Old Male with Road Traffic Accident – Left Side Injury

Figure 3.1: Pre-operative and Post-operative X-ray (left side)





1 month follow up X ray



3 month follow up Xray



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