**International Journal of Orthopaedics Research**
**www.orthopaedicsjournal.in**
**E-ISSN: 2663-0923, P-ISSN: 2663-0915**
**Received: 25-05-2025, Accepted: 24-06-2025, Published: 19-07-2025**
**Volume 7, Issue 2, 2025, Page No. 6-11**

# Comparative evaluation of clinical and functional outcomes of suprapatellar versus infrapatellar nailing in tibial shaft fractures: A Prospective study

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**Abstract**
**Background:** Tibia and fibula shaft fractures are pervasive, constituting the lion's share of long bone injuries in adults. Tibial shaft fractures, making up about 2% of all fractures, often necessitate surgical intervention. While the traditional infra-patellar approach for intramedullary nail fixation is commonplace, it encounters challenges in proximal third tibia shaft fractures, resulting in deformities and persistent postoperative knee pain. The use of suprapatellar intramedullary nail fixation to treat tibial shaft fractures has grown in acceptance and interest. Therefore, the purpose of the current study was to evaluate and compare the clinical, functional and radiological union and complications in fractures of shaft of tibia nailing with supra-patellar approach and infrapatellar approach.
**Materials and Methods:** The present prospective and comparative clinical study was conducted for a period of 2 years on 40 patients with tibial shaft fractures admitted under the Department of Orthopaedics, SSIMS and RC, Davangere. All the patients who fulfilled inclusion criteria were eligible for the study. After obtaining physical fitness for surgery, the subjects were surgically managed with intramedullary nailing either through suprapatellar approach or infrapatellar approach. The outcome was assessed based on Lysholm score, Lower extremity functional scale and Klemm's and Borner's criteria.
**Results:** The average time of fracture healing was comparable in both the Suprapatellar nailing (SPN) and Infrapatellar nailing (IPN) groups i.e ~17weeks. Anterior knee pain was noted in 26.31% of the IPN group whereas it was nil in the SPN group which was statistically significant ($p < 0.05$). Excellent results were observed in 42.10% of IPN cases, whereas 60% of SPN cases showed excellent outcomes according to Klemm's criteria.
**Conclusion:** The findings suggest that the suprapatellar nailing approach may offer better surgical efficiency, reduced blood loss, improved functional recovery, and fewer complications compared to the infrapatellar technique.

**Keywords:** Intramedullary nailing, tibial shaft fractures, suprapatellar approach, infrapatellar approach

## Introduction
Tibial fractures are the most common fractures in the human body. [1, 2] The bimodal appearance of tibial fractures includes both younger and older age groups, with peaks occurring at the ages of 20 and 50 respectively. Tibia shaft fractures are a common traumatic injury brought on by either low-energy trauma, like falls in older adults, or high-energy trauma, such as motor vehicle accidents in young patients. It accounts for about 2% of all adult fractures. [3, 4]
Both conservative and surgical approaches can be used to treat tibial fractures. Tibial shaft fractures can be treated surgically in a number of ways, including internal fixation, such as intramedullary nailing and plating, and external fixator application. For the treatment of tibial shaft fractures, intramedullary nailing has been regarded as the gold standard since it can offer good fracture reduction, shorter time to bear weight, high union rates and permits early mobilization. [5, 10]
Historically, infrapatellar intramedullary nailing (IMN) has been a popular surgical technique for treating tibial shaft fractures since it is minimally invasive and enables early functional recovery. [11] But because of quadriceps muscle force, which causes proximal fracture fragments to extend when the knee is in flexion and increases the risk of valgus and procurvatum deformities following tibial nailing, IMN insertion through the infrapatellar (IP) approach remains technically difficult. [12, 13] Additionally, chronic postoperative anterior knee pain is one of the most frequent side effects after IMN through IP approach. [14, 15]
Thus in 1996, Tornetta and Collins[16] introduced a new technique for proximal tibia fractures using a semi-extended approach. The approach was developed to reduce the force of the quadriceps tendon on the proximal fragment and mitigate the valgus and apex anterior deformities typically seen in this fracture pattern. This approach also simplifies radiographic imaging and lowers malalignment of distal tibia fractures. [17, 18] Although there are some debates about the suprapatellar (SP) technique using the semi extended position, it has not yet been established that it can cause cartilage and joint damage.
So, the purpose of this study is to analyse the clinical, functional and radiological outcomes in suprapatellar nailing and infrapatellar nailing technique for tibial shaft fractures.

## Materials and Methods
The present study was done in the Department of Orthopaedics, SS Institute of Medical Sciences Davangere, Karnataka, India, from February 2023 to February 2025. The ethical committee of the institute was informed about the objectives of the study and the ethical clearance certificate was obtained from them.
The following were the inclusion criteria: Extra-articular tibia fractures, all skeletally mature patients. (>18 years and < 80 years), Simple/Closed fracture, Compound Type 1 And Type 2 fractures. (according to Gustilo-Anderson Classification)
The following were the exclusion criteria: Compound type 3 fractures (according to Gustilo-Anderson Classification), age (< 18yrs and > 80years), ipsilateral knee injury, severe

ankle diseases such as Rheumatoid and Gouty Arthritis.
40 patients satisfied the criteria and were enrolled in the study.
The principal investigator clinically examined the patient. Routine investigations and preoperative radiographs of the patients were done. Informed written consent for surgery was obtained. Patient underwent tibial nailing by either suprapatellar or infrapatellar technique.

**Nails Used in The Study:** Nails of diameters of 8, 9 and 10mm and with length from 280mm-380 mm with increments of 20 mm were used for tibia interlocking. For locking there are 2 holes at the proximal end and 3 at the distal end for the Infrapatellar IMIL nail. There are 4 holes at the proximal end and 3 at the distal end for the Suprapatellar IMIL nail. Locking bolts are self-tapping, 4.9 mm and 3.9 mm available from 22-60 mm in 2 mm increments and upto 80 mm in 5 mm increments.

**Fig 1:** Infrapatellar IMIL nail

**Fig 2:** suprapatellar imil nail

**Technique of Infrapatellar Approach:** All patients were positioned supine
on the radiolucent table. The injured leg was positioned freely, with knee flexed 90 degrees over the edge of operating table to relax the gastro-soleus muscle and allow traction by gravity. A vertical patellar tendon splitting incision over skin extending from center of the inferior pole of patella to the tibial tuberosity, about 5cm long is made. Patellar tendon is vertically split in its middle and retracted to reach the proximal part of tibial tuberosity. Entry point is determined. In the AP view the entry point is in line with the axis of the intramedullary canal and with the lateral tubercle of the intercondylar eminence. In lateral view the entry point is at the ventral edge of the tibial plateau. A curved bone awl was used to breach the proximal tibial cortex in a curved manner, so that from perpendicular position, its handle comes to be parallel to the tibial shaft. Guide wire was passed and then nail was inserted over the guide wire from the entry point after provisional reduction by manipulation and traction.

**Technique of Suprapatellar Approach:** All patients were positioned
supine on the radiolucent table. The injured leg was positioned freely, with knee flexed 20 degrees over the operating table. The skin incision began at the superior pole of patella and proceeding 5cm proximally. The quadriceps tendon was split longitudinally and the knee joint was entered from above. The ideal starting point is just medial to lateral tibial spine. On the lateral view the entry point is anterior to the articular margin. A specialized insertion cannula within a protection sleeve was placed at the desired entry point through the trochlear groove under the patella. Following that nail was inserted using the specific insertion cannula in accordance with the protocol.

**Post Op Care:** Following surgery, the patients were instructed to move their ankle, knee and toes. On the $5^{th}$ post-operative day, or after five days of IV antibiotics, the patients were discharged from the hospital; they were instructed to move their ankle, knee and toes. It was forbidden for them to bear weight on the operated limb. On the $12^{th}$ postoperative day, during the follow-up, the sutures/staples were removed.

**Follow Up:** Patients were followed up at 4 weeks, 8 weeks, 12 weeks, 6 months and 1 year postoperatively with serial x rays. They underwent a thorough clinical examination, with particular attention paid to the range of motion in the knee and ankle as well as any subjective symptoms. Lysholm score, Lower extremity functional scale (LEFS) and Klemm and Borner's Criteria were used to assess the functional outcome. Radiological outcome was assessed based on the grade of callus formation observed radiologically.

## Statistical Analysis

Statistical analysis was carried out using SPSS version 25. Quantitative data was expressed as Mean ± SD. Qualitative data was expressed as numbers and percentages. Student's t-test, chi square test and other suitable tests of significance were applied at the time of statistical analysis. P values of <0.05 was considered statistically significant.

## Results

The mean age in the IPN group (43.30±15.60) was slightly higher than in the SPN group (37.95±12.57), though the difference was not statistically significant. Males constituted the majority in both groups—80% in IPN (16 out of 20) and 65% in SPN (13 out of 20). The gender distribution difference was also not statistically significant. (Table 1)

**Table 1:** demographic characteristics of study population Between infrapatellar nail and suprapatellar nail techniques

| Variables | IPN (N=20) | SPN (N=20) | p-value |
|---|---|---|---|
| Age in years (Mean ± SD) | 43.30±15.60 | 37.95±12.57 | 0.240 (NS) |
| ***Sex*** | | | |
| Male (N, %) | 16 (80%) | 13 (65%) | 0.144 (NS) |
| Female (N, %) | 4 (20%) | 7 (35%) | |

Table 2 compares the mean surgical time, showing that the IPN group had a shorter duration (86.25±8.58 minutes) compared to the SPN group (97.00±13.41 minutes). The difference was statistically significant (p=0.006).

**Table 2:** comparison of mean surgical time (min) between Infrapatellar nail and suprapatellar nail techniques

| Groups | N | Mean±SD | 95% CI | t-value | p-value |
|---|---|---|---|---|---|
| IPN | 20 | 86.25±8.58 | -18.21 to - 3.28 | 2.916 | 0.006 (HS) |
| SPN | 20 | 97.00±13.41 | | | |

Table 3 evaluates blood loss during surgery. The mean blood loss was higher in the IPN group (97.50±10.19 mL) compared to the SPN group (84.50±10.50 mL). This difference was statistically significant (p=0.000).

**Table 3:** comparison of mean blood loss (ml) between infrapatellar nail and suprapatellar nail techniques

| Groups | N | Mean±SD | 95% CI | t value | p-value |
|---|---|---|---|---|---|
| IPN | 20 | 97.50±10.19 | 6.37 to 19.62 | 3.972 | 0.000 (HS) |
| SPN | 20 | 84.50±10.50 | | | |

Table 4 compares the mean union time, which was slightly lower in the IPN group (16.70±2.84 weeks) than in SPN (17.00±3.81 weeks), though this difference was not statistically significant.

**Table 4:** comparison of mean union time (weeks) between Infrapatellar nail and suprapatellar nail techniques

| Groups | N | Mean±SD | 95% CI | t-value | p-value |
|---|---|---|---|---|---|
| IPN | 19 | 16.70±2.84 | - 2.45 to 1.85 | - 0.282 | 0.780 (NS) |
| SPN | 20 | 17.00±3.81 | | | |

Table 5 compares postoperative complications. In the IPN group, anterior knee pain was noted in 26.31% (5 cases), superficial infections in 15.78% (3 cases), and fat embolism in 5.26% (1 case). In the SPN group, 80% had no complications; however, 15% (3 cases) had superficial infections, and 5% (1 case) experienced delayed union. The differences were not statistically significant.

**Table 5:** comparison of complications between infrapatellar nail and suprapatellar nail techniques

| Variables | IPN | SPN | $X^2$ value | p-value |
|---|---|---|---|---|
| Nil | 10 (50%) | 16 (80%) | 8.364 | 0.079 (NS) |
| Fat Embolism Syndrome | 1 (5%) | 0 | | |
| Superficial Infection | 3 (15%) | 3 (15%) | | |
| Anterior Knee Pain | 5 (25%) | 0 | | |
| Delayed union | 0 | 1 (5%) | | |
| Deep infection | 1 (5%) | 0 | | |
| TOTAL | 20 (100%) | 20 (100%) | | |

Table 6 compares LEFS at 12 months, where the mean score was 71.60±3.37 in IPN and 75.35±3.03 in SPN. The difference was statistically significant (p=0.01).

**Table 6:** Comparison of Mean Lower Extremity Functional Scale At 12 Months Between Ipn And Spn Techniques

| Groups | N | Mean±SD | 95% CI | t-value | p-value |
|---|---|---|---|---|---|
| IPN | 19 | 71.60±3.37 | - 5.80 to -1.69 | -3.695 | 0.01 (S) |
| SPN | 20 | 75.35±3.03 | | | |

Table 7 compares the Lysholm score at 12 months, which was significantly lower in the IPN group (87.25±4.49) than in SPN (92.60±4.86), with p=0.001.

**Table 7:** Comparison of Mean Lysholm Score At 12 Months Between Infrapatellar Nail and Suprapatellar Nail Techniques

| Groups | N | Mean±SD | 95% CI | t-value | p-value |
|---|---|---|---|---|---|
| IPN | 19 | 87.25±4.49 | - 8.34 to -2.35 | -3.614 | 0.001 (HS) |
| SPN | 20 | 92.60±4.86 | | | |

Table 8 assesses functional outcomes using Klemm's criteria. Excellent results were observed in 42.10% of IPN cases, whereas 60% of SPN cases showed excellent outcomes.

**Table 8:** Comparison of Klemm's Criteria Between Infrapatellar Nail and Suprapatellar Nail Technique

| Variables | IPN | SPN | $X^2$ value | p-value |
|---|---|---|---|---|
| Excellent | 8 (42.10%) | 17 (85%) | 9.840 | 0.007 (HS) |
| Good | 6 (31.57%) | 3 (15%) | | |
| Fair | 5 (26.31%) | 0 | | |
| Total | 19 (100%) | 20 (100%) | | |

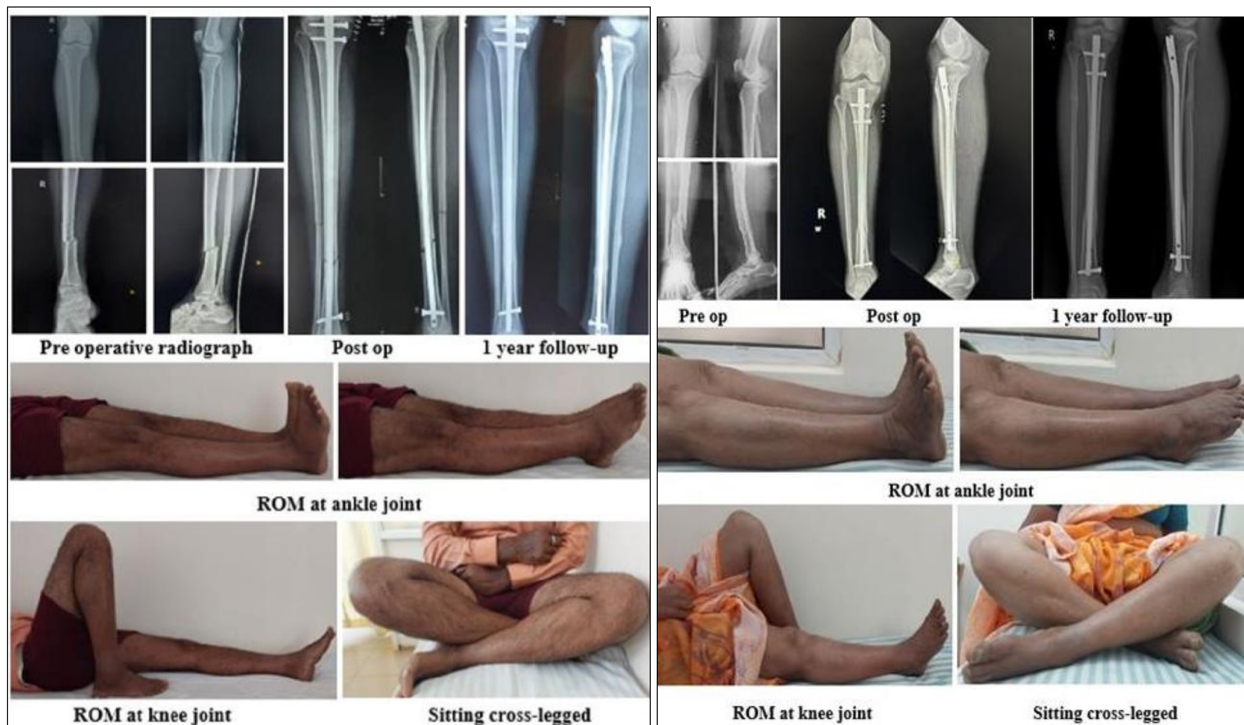


**Fig 3,4:** Radiographs and Clinical images. (SP approach) and (IP approach)

**Discussion**

Tibial shaft fractures are a common orthopaedic issue that often require surgical intervention to restore lower limb stability and function. The choice of surgical technique plays a pivotal role in determining the success of the procedure and overall patient outcomes. While extensive research has been conducted comparing suprapatellar and infrapatellar nailing techniques, there remains no clear consensus on which method yields superior results in terms of surgical efficiency, postoperative complications, and patient-reported recovery.

**Demographic Details of Study Participants:** In the study, the mean age of participants in the IPN group was 43.30±15.60 years, while in the SPN group, it was 37.95±12.57 years, with an overall mean age of 39.6 years. These results align with a study by Gupta *et al*. [19] which included participants within a similar age range. Nimavat *et al*. [20] reported a median age of 34 years in the IPN group and 37 years in the SPN group, which was slightly lower than the median age in the current study. Additionally, a retrospective review by Larsen *et al*. [21] found the mean age at the time of fracture to be 38.5 years (±21.2 SD). Regarding gender distribution, 80% of patients in the IPN group were male, and 20% were female. In the SPN group, 65% were male, and 35% were female. These findings differ from those of Gupta *et al*. and Nimavat *et al*., where 80% of the SPN group comprised males. [19, 20] Tibial shaft fractures have an incidence rate of 16.9 per 100,000 per year, with males experiencing a higher rate (21.5 per 100,000 per year) and the highest frequency occurring between the ages of 10 and 20. For females, the incidence rate is 12.3 per 100,000 per year, with peak occurrence between 30 and 40 years.

**Mode of Injury:** Road traffic accidents (RTAs) were identified as the leading cause of tibial shaft fractures, accounting for 70% of cases in the SPN group and 78.94% in the IPN group. These results are consistent with previous studies, which have also highlighted RTAs as the primary cause of tibial fractures. Tibial shaft fractures represent approximately 37% of all long bone fractures in adults and are commonly associated with high-energy trauma, such as RTAs and sports injuries. [22]

**Mean surgical time:** The IPN approach required less operating time (86.25±8.58 minutes) compared to the SPN technique (97.00±13.41 minutes). Initially, the suprapatellar group showed a longer average surgical time, primarily due to the learning curve in the first few cases. However, as proficiency with the technique improved, the surgical time became comparable to or even shorter than that of the infrapatellar approach. A study by Al-Azzawi *et al*.[23] reported an average surgical duration of 110 minutes for SPN and 139 minutes for IPN. Another study found mean surgical times of 87.25 minutes for SPN and 92.20 minutes for IPN. A meta-analysis revealed an average difference of -5.62 minutes in operative time, with a 95% confidence interval of -11.88 to 0.63, indicating no statistically significant difference. [24]

**Mean Blood Loss:** Blood loss was greater in the IPN group (97.50±10.19 mL) compared to the SPN group (84.50±10.50 mL). Research by Gao *et al*. [25] suggests that the suprapatellar approach significantly reduces blood loss compared to the infrapatellar technique. A meta-analysis by Wang *et al*. [26] also concluded that suprapatellar nailing leads to lower total blood loss.

**Union Time:** In this study, the mean union time was 16.70±2.84 weeks for the IPN group and 17.00±3.81 weeks for the SPN group. Joshi *et al*. [27] reported a slightly shorter union time for suprapatellar nailing, a finding that aligns with this study. Generally, tibial shaft fractures heal within 4 to 6 months, though factors such as fracture severity, patient

health, and adherence to post-operative care influence healing duration.

**Functional Outcomes:** Functional recovery was assessed using the Lysholm Knee Score, Lower Extremity Functional Scale (LEFS), and Visual Analog Scale (VAS) for pain. The SPN group demonstrated significantly better functional recovery at three and six months compared to the IPN group. The Lysholm Knee Score at six months was 92.60±4.86 in the SPN group and 87.25±4.49 in the IPN group (p = 0.001), indicating faster knee function recovery with the SPN approach. This could be attributed to the SPN technique's ability to reduce patellar tendon and extensor mechanism irritation. Research by Courtney *et al.* [28] and Yang *et al.* [29] supports these findings, demonstrating improved knee function and earlier weight-bearing in the SPN group.
Based on Klemm's criteria, 42.10% of IPN cases had excellent outcomes, while 60% of SPN cases achieved excellent results.

**Post-Surgical Complications:** The SPN group reported lower pain scores on the VAS, consistent with findings from MM Rakesh *et al*., [30] who noted reduced anterior knee pain with the suprapatellar technique. In this study, 26.31% of IPN cases experienced anterior knee pain. This could be caused by iatrogenic injury to the infrapatellar nerve, Hoffa's fat pad, periosteal irritation of the entry point, patellar tendinopathy or nail prominence. One IPN patient developed deep infection 22 days post-surgery, necessitating implant removal, medullary wash, external fixation, and intravenous antibiotics and hence has been removed from the functional outcomes. The patient achieved union at 24 weeks. According to Wang *et al*., [26] the suprapatellar approach is associated with lower fracture risk, better knee function recovery, reduced knee pain, and shorter fluoroscopy time compared to the infrapatellar technique.

**Study Limitations**

- **Small Sample Size:** The study included only 40 patients (20 per group), limiting the generalizability of findings. Larger studies would provide more robust conclusions.

- **Short Follow-Up Duration:** A one-year follow-up may not be sufficient to evaluate long-term complications such as non-union, late infections, and long- term functional recovery. Longer follow-ups would offer more comprehensive insights.

- **Patient Discontinuation:** In the IPN group, one patient was withdrawn from the study due to post-surgical complication. As the patient's condition required implant removal, no data on functional or clinical outcomes were collected.

**Conclusion**

The suprapatellar approach outperformed the infrapatellar approach in terms of functional outcomes at the final follow up. It is noteworthy that anterior knee pain was absent with the suprapatellar technique but present in 26% of individuals with the infrapatellar approach. Initially, the suprapatellar group showed a longer average surgical time, primarily due to the learning curve in the first few cases. However, as proficiency with the technique improved, the surgical time became comparable to or even shorter than that of the infrapatellar approach. Moreover, there is reduced blood loss too in the suprapatellar group highlighting better surgical efficiency. The duration of full weight bearing and fracture union did not differ significantly. In conclusion, suprapatellar approach is a better and reliable alternative to the infrapatellar approach in the management of tibial shaft fractures.

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