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Original Article

Orthopaedics Section

Suprapatellar versus Infrapatellar Approach for Intramedullary Nailing in Tibial Shaft Fractures: A Prospective Interventional Study

GIRISH SAHNI[1], SUKHJOT SINGH[2], ASHISH KAVIA[3], HARI OM AGGARWAL[4], HARJIT K SINGH CHAWLA[5]

ABSTRACT

Introduction: Tibial diaphyseal fractures are the most prevalent type of tibia fracture. A well known surgical method for treating tibial shaft fractures was the traditional infrapatellar approach for tibia Intramedullary Nailing (IMN). However, due to increased valgus and procurvatum deformities, IMN insertion through the infrapatellar route poses problems. Recently, suprapatellar nailing in the semi-extended position has been promoted as a safe and effective surgical treatment.

Aim: To compare the clinical and functional outcomes of tibial shaft fractures treated with IMN utilising the Suprapattelar (SP) and Infrapatellar Methods (IP).

Materials and Methods: A prospective interventional study was conducted on 40 patients, in the Department of Orthopaedics, in Government Medical College, Patiala, Punjab, India from November 2019 to May 2021. The patients were divided into two groups on the basis of tibial shaft fractures treated with IMN utilising the SP and those treated with IP techniques during a two-year period (20 in each group) with six months follow-up. Group A patients were treated with IMN in tibia through suprapatellar technique and group B Patients were treated with IMN in tibia via infrapatellar approach. The outcomes of IMN in tibial shaft fractures via SP and IP approach were compared in terms of fluoroscopy time, average surgical time, anterior knee pain using Visual Analogue Scale (VAS) score, average blood loss, fracture union time and functional outcome (in terms of the lower extremity functional score). For statistical analysis Student's t-test and Chi-square test was used, p-value <0.05 was considered as significant.

Results: There were significant differences between SP and IP IMN in terms of fluoroscopy duration (94.25 vs 129.40 seconds, p-value-0.001), anterior knee pain (VAS score) (19.65 vs 29.85, p-value-0.001), average blood loss (49.30 vs 62.45 mL, p-value=0.001), and functional result (75.45 vs 70.05, p-value=0.001). The fracture union time between the two groups was non significant (90.50 vs 90.30 days, p-value=0.876).

Conclusion: In terms of fluoroscopy time, anterior knee pain, average blood loss, and knee ratings, the SP technique was superior to the IP strategy.

Keywords: Anterior knee pain, Fluoroscopy time, Fracture union time, Functional outcome

INTRODUCTION

The most common long bone fractures are tibia and fibula shaft fractures. Tibial diaphyseal fractures are the most common type of tibia fracture. Fibular fractures were present in 80% of these cases. [1]. Adult tibia diaphyseal fractures were most common in young males between the ages of 15 and 19 years, with an annual incidence of 109 per 100,000 people. Adult tibia diaphyseal fractures were most common in women between the ages of 90 and 99 years, with an annual incidence of 49 per 1,000 population. [2] Among all long bones, diaphyseal tibia fractures have a rather significant risk of non union and malunion of tibial shaft fractures have a bimodal distribution, with, low-energy spiral fractures more common in individuals over 50 years old and high-energy transverse and comminuted fractures more common in patients under 30. Falls from a standing height and sports injuries are the most prevalent causes of low-energy tibial fractures, whereas vehicle trauma is the most common cause of high-energy tibial diaphyseal fractures [1].

In the adult population, intramedullary nail fixation remains the treatment of choice for displaced and unstable tibial shaft fractures. Intramedullary nail fixing provides the advantage of requiring minimum surgical dissection and preserving the fracture's extraosseous blood supply. The use of intramedullary nail fixation was more limited to proximal and distal metaphysis fractures [3]. A well-known surgical method for treating tibial shaft fractures was the traditional infrapatellar approach for tibia IMN However, due to quadriceps muscle power causing proximal fracture fragment displacement with the knee in flexion and an increased likelihood of valgus and procurvatum deformities following tibial nailing, IMN insertion through the infrapatellar route poses problems [3].

Recent advances in nail design and reduction procedures have expanded the criteria for intramedullary nail fixing to include both proximal and distal tibia fractures including the metaphyseal area. Recently, suprapatellar nailing in the semi-extended position has been promoted as a safe and effective surgical treatment. The method allows for the selection of an acceptable beginning point in a semi-extended posture, which aids in fracture reduction (particularly in apex anterior deformities). Preliminary clinical data shows promising results, including a low percentage of post procedure knee pain [4]. As there were only few studies [5-9] done in past on this topic hence, the present study was conducted with an aim to compare the clinical and functional outcomes of tibial shaft fractures treated with IMN utilising the SP and IP methods.

MATERIALS AND METHODS

A prospective interventional study was conducted in the Department of Orthopaedics, in Government Medical College Patiala, Punjab, India, from November 2019 to May 2021 on 40 patients. The Institutional Ethical Committee approval was obtained (letter number BFUHS/21k21p-TH/5468). Informed consent was obtained from the subjects. Group A patients treated with IMN tibia through SP technique and group B patients treated with IMN tibia via IP approach were chosen through alternate odd and even numbers, who presented to the department during the study period. A total of 40 fracture shaft tibia cases were included and Arbeitsgemeinschaft

für Osteosynthesefragen (AO) fracture classification was used to grade the fractures [10].

Inclusion criteria: Age >18 years to <65 years, closed fractures of shaft tibia and fibula, open fractures of both bone legs up to Gustilo Anderson classification 3A [11], segmental fractures of tibia. Proximal third and distal third tibia shaft fractures, all diaphyseal fractures of tibia, and patients medically fit for surgery.

Exclusion criteria: Age <18 years, open fractures of both bone legs, Gustilo Anderson classification 3B and 3C [11], old neglected shaft tibia fractures, intra-articular extension of fracture, and canal size less than 7 mm.

Study Procedure

Surgical approach: In the present study, tibial shaft fractures were fixed with IMN via midline patellar tendon split IP and SP approach [Table/Fig-1].

Approach	SP	IP
Patient positioning	Supine with the knee in semi-flexed position (10-30 degrees)	Supine with the knee in 90° flexion and the leg hanging in the air
Technique	1-1.5 cm proximal to the superior pole of the patella, a 2-3 cm midline longitudinal skin incision was made. The quadriceps tendon was exposed and a midline longitudinal split was made in the tendon fibers. Suprapatellar recess was accessed and the finger of the surgeon was used to break any adhesion between the patella and the undersurface (special protection sleeve was required for protecting the patella femoral cartilage)	A 2-3 cm midline longitudinal skin incision was made over the patellar tendon. The patellar tendon was split in the midline and the bare area of the tibia was felt.
Ideal entry point	AP view-just medial to the lateral tibial spine. Lateral view- at the transition between articular surface and anterior cortex of the tibia.	AP view- just medial to the lateral tibial spine. Lateral view- at the transition between the articular surface and anterior cortex of the tibia. But the knee was flexed to 130° to gain the ideal entry point.

[Table/Fig-1]: Overview of SP vs IP approach.
AP veiw: Anteroposterior view

Standard surgical technique of IMN insertion: Nail was inserted over the guide wire from the entry point made on the bare area of the tibia after provisional reduction by manipulation and traction.

Postoperative protocol: Intravenous antibiotics (2nd generation cephalosporins and aminoglycosides) for two days and on postoperative day one was administered and passive and active range of motion exercises at the knee and ankle joint was allowed. Partial weight bearing was allowed at six weeks and once the signs of fracture healing were present on x-rays, then full weight bearing was allowed.

Follow-up: After surgery, patients were followed-up at six weeks, three months, and six months. At each follow-up, serial AP and lateral X-ray images were collected, and the patient was assessed for radiological and clinical signs of the union. The lower extremity functional scale [12] was used to assess the functional outcome. The functional outcomes of IMN in tibial shaft fractures via SP and IP approach were compared in terms of fluoroscopy time, average surgical time, anterior knee pain (VAS score) [13], average blood loss, fracture union time, the functional outcome in terms of the lower extremity functional score. The maximum score for 20 related daily activities was 80. Each activity received a maximum of four points. A score of 70-80 implied an excellent functional outcome. A score of 60-70 indicated a good functional outcome. A score of 40-60 suggested a fair functional outcome. A score of less than 40, had a poor functional outcome.

Functional definitions:

Average blood loss: Average blood loss that occurs during the time of surgery.

Anterior knee pain: Pain that occurs in the anterior and central aspect of the knee. It was measured using the VAS scale [13].

Fracture union time: Time duration after the surgery to the union, which is calculated by the functional outcome score [12].

STATISTICAL ANALYSIS

The IBM Statistical Package for the Social Sciences (SPSS) 22.0 version was used for statistical analysis. The Student's t-test and the Chi-square test were used to compare the outcomes between the groups. It was considered significant, if the p-value was less than 0.05.

RESULTS

Patients' socio-demographic data, such as age, gender, and fracture type, were evenly distributed between the two groups [Table/Fig-2]. The mean surgical time in group A was 87.25±13.98 minutes and in group B was 92.20±9.27 minutes (p-value=0.195) as shown in [Table/Fig-3].

Characteristics	Group A	Group B	p-value (t-test)
Age (years)	47.75±9.43	42.8±9.11	0.100
Sex (M/F)	13/7	13/7	0.264
AO classification 41A2/42A1/42A2/42A3/ 42B2/42C2	2/2/3/10/2/1	2/2/2/12/1/1	0.697

[Table/Fig-2]: Socio-demographic parameters.

Average surgical time (minutes)	Mean	Std. Error mean	t-test	p-value	95% CI	
Group A	87.25±13.98	3.13	-1.320	0.195 (NS)	-12.54	2.64
Group B	92.20±9.27	2.07			-12.58	2.68

[Table/Fig-3]: Average surgical time.

Average blood loss in group A was 49.30±12.27 mL and in group B was 62.45±6 mL (p-value=0.001) [Table/Fig-4].

The average fluoroscopy time in group A was 94.25±8.66 seconds and in group B was129.40±6.58 seconds (p-value=0.001) [Table/Fig-5].

The mean VAS Score in group A 19.65±2.21 and in group B was 29.85± 2.68 (p-value=0.001) [Table/Fig-6].

Average blood loss (mL)	Mean	Std. Error mean	t-test	p-value	95% CI	
Group A	49.30±12.27	2.74	-4.306	0.001 (HS)	-19.33	-6.97
Group B	62.45±6.00	1.34			-19.41	-6.89

[Table/Fig-4]: Average blood loss.

Fluoroscopy time (seconds)	Mean	Std. Error mean	t-test	p-value	95% CI	
Group A	94.25±8.66	1.94	-14.450	0.001 (HS)	-40.07	-30.23
Group B	129.40±6.58	1.47			-40.09	-30.21

[Table/Fig-5]: Fluoroscopy time.

Anterior knee pain (VAS)	Mean	Std. Error mean	t-test	p-value	95% CI	
Group A	19.65±2.21	0.49	-13.136	0.001 (HS)	-11.77	-8.63
Group B	29.85±2.68	0.60			-11.77	-8.63

[Table/Fig-6]: Average knee pain (VAS).

Average fracture healing time in group A was 90.50±3.32 and in group B was 90.30± 4.61 (p-value=0.876) [Table/Fig-7]. The mean lower extremity function score in group A was 75.45±2.09 and in group B was 70.05±3.05 (p-value=0.001) [Table/Fig-8]. A score of

70-80 i.e. excellent functional outcome was seen in all 20 patients in suprapatellar and in 14 in infrapatellar approaches. In six patients with infrapatellar approaches, good outcome was observed. [Table/Fig-9] shows x-rays of pre and postoperative images.

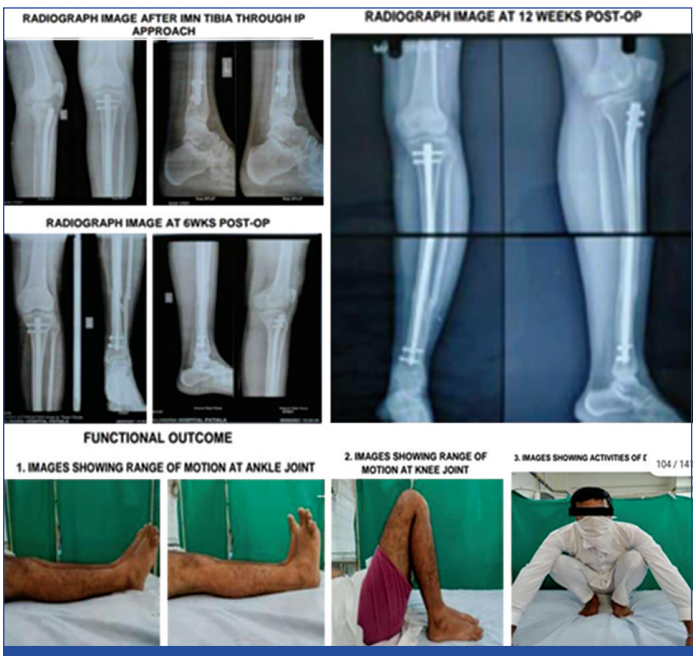
Fracture healing time (Days)	Mean	Std. Error mean	t-test	p-value	95% CI	
Group A	90.50±3.32	0.74	0.157	0.876 (NS)	-2.37	2.77
Group B	90.30±4.61	1.03			-2.38	2.78

[Table/Fig-7]: Fracture healing time.

Lower extremity function score	Mean	Std. Error mean	t-test	p-value	95% CI	
Group A	75.45±2.09	0.47	6.530	0.001 (HS)	3.73	7.07
Group B	70.05±3.05	0.68			3.72	7.08

[Table/Fig-8]: Lower extremity function score.

[Table/Fig-9a]: Pre and postoperative clinical and radiological images (SP approach). ROM: Range of Motion



[Table/Fig-9b]: Pre and postoperative clinical and radiological images (IP approach).

DISCUSSION

As intramedullary nails cause minimal stress to adjacent soft tissues, have a lesser risk of malunion, and provide greater biomechanical strength, IMN is becoming more popular, as a therapy for tibia fractures.The standard IP method and the SP approach in a semi-extended position are used for IMN implantation [11]. The mean surgery time was similar in both groups, which was in line with Wang C et al., [11], they exhibited a reduction in fluoroscopy time while maintaining the same overall operational time. Ponugoti N et al., [14], who did a meta-analysis comparing SP with IP, found similar results.

In a meta-analysis of SP versus IP IMN, Xu H et al., [15] found that in the SP approach fluoroscopy time was reduced. This could be due to the semi-extended position, which allows for easier leg handling and access to the fluoroscopic image intensifier throughout the process [16]. Packer TW et al., came to similar conclusions in their research. Because of the frequent use of intraoperative fluoroscopy, orthopaedic teams are exposed to greater radiation doses, which can raise the risk of thyroid cancer [17]. As a result, the SP method is useful in lowering this risk for both the surgeon and the patient.

During the IP IMN technique, the average blood loss was greater. These findings were consistent with those of Yang L et al., who found comparable results in their study [18]. Reducing perioperative blood loss was an important issue that promoted recovery and decreased blood transfusion requirements. The VAS pain score in the SP group was considerably lower than in the IP group, according to the present study. This finding is congruent with that of MacDonald DRW et al., [19], who evaluated VAS scores between the IP and SP procedures in 95 patients and found that the IMN insertion via SP approach is linked with less postoperative anterior knee discomfort than the IMN via IP approach [19]. Patellar tendon splitting leading to the involvement of the infrapatellar nerve and intra-articular structural damage were all causes of postoperative knee pain, which the suprapatellar technique attempts to prevent [15]. According to Yang L et al., [18] meta-analysis, the SP method was linked to a considerable drop in VAS scores.

The average fracture healing time was comparable across the SP and IP IMN approaches in the present study. The results were comparable to the study by Chen X et al., [5] who found no significant difference in fracture union time between the two groups. Because postoperative anterior knee discomfort was substantially reduced in the SP group due to early rehabilitation, the lower extremity functional score was higher in the SP group. The findings are in line with those of Gao Z et al., [6] and Ponugoti N et al., [14]. According to a study by Lu Y et al., [7], the percentage of malalignment in the SP group was 4.8%, which was much lower than the rate of 14.3% in the IP group, which was in concordance with the index study. In addition, Stella M et al., found that the IP group had a 26.1% incidence of angular deformity [20].

In the IP group, the pull of the quadriceps caused flexion of the proximal fragment, resulting in procurvatum and valgus deformity. In the SP approach, since the knee joint was in a semi-flexed position (10-30° flexion) which allowed the quadriceps to relax and also guided the nail to gain an appropriate starting point, the blocking effect of the patella was also lost. All these factors lead to improvement in deformity rates [8]. The future recommendation would be that, study could be conducted on a large sample size, to generalise the findings.

Limitation(s)

The present study was limited by it's small sample size. Randomisation was not done for the allocation of the participants and it was one of the limitations, which could cause selection bias.

CONCLUSION(S)

The SP strategy resulted in better functional outcomes, less pain, less fluoroscopy time and radiation exposure, and a lower average total blood loss than the IP approach. As a result, the IMN via SP method, can be deemed as the most successful therapeutic approach for the treatment of tibial shaft fractures.

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PARTICULARS OF CONTRIBUTORS:
1. Professor, Department of Orthopaedics, Government Medical College, Patiala, Punjab, India.
2. Junior Resident, Department of Orthopaedics, Government Medical College, Patiala, Punjab, India.
3. Assistant Professor, Department of Physical Medicine and Rehabilitation, Government Medical College, Patiala, Punjab, India.
4. Professor, Department of Orthopaedics, Government Medical College, Patiala, Punjab, India.
5. Assistant Professor, Department of Orthopaedics, Government Medical College, Patiala, Punjab, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. Harjit K Singh Chawla,
Assistant Professor, Department of Orthopaedics, Government Medical College, Patiala, Punjab, India.
E-mail: harjitchawla@gmail.com

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