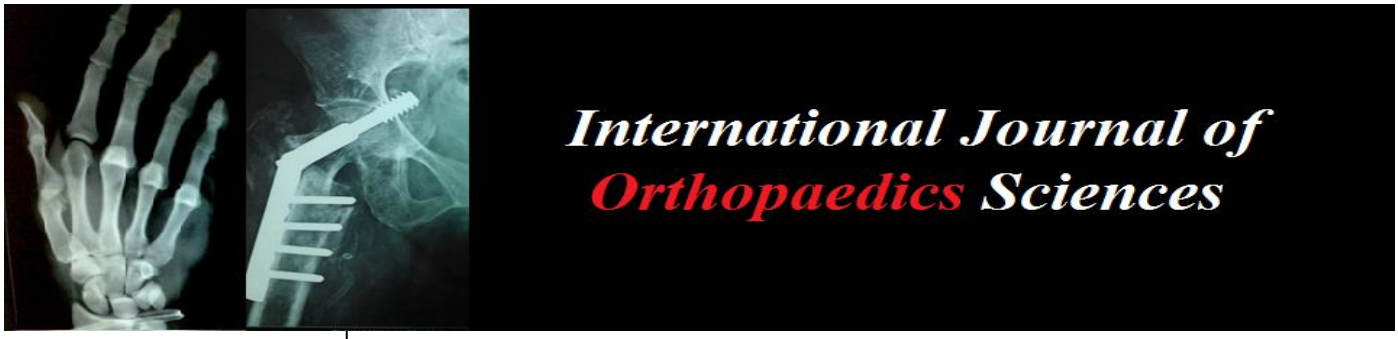

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Comparative study of functional outcome in upper one third shaft tibia fractures with suprapatellar and infrapatellar intramedullary tibial nailing

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Abstract
The main agenda of this research study was to create a comparison between the outcomes, both clinical and functional, of suprapatellar versus infrapatellar tibial nail insertion for upper one-third shaft fractures of the tibia. Randomized controlled trials' meta-analysis was performed, looking at variables such operating time, blood loss, Lysholm knee score, visual analog scale for pain, range of motion, time of union, duration of hospital stays, long-term deformity occurrences, and radiographic outcomes.
Compared to the infrapatellar method, the suprapatellar technique showed a number of advantages. Total bleeding, discomfort levels on a visual analog scale, and fluoroscopy times all decreased significantly as a result. Additionally, the suprapatellar group scored significantly higher on Lysholm knee evaluations. In line with expectations, callus development and fracture healing took place between 6 and 8 weeks and 14 to 20 weeks, respectively.
Due to its stable fixation and decreased risk of soft tissue injury, intramedullary nailing has traditionally been used to treat tibial shaft fractures, which are frequently caused by trauma of a greater intensity. The prevalence of postoperative knee pain was much reduced with the suprapatellar approach. When the operational times of the two groups are compared, it is evident that the operational times are longer in the infra group, with a t value of 33.061 and a statistically significant p value of <0.001. With a t value of 8.744 and a p value of <0.001, a comparison of the blood loss (mops used) between the two groups reveals that the infrared group's blood loss (mops used) is higher.
When the VAS of the two groups is compared, the infra group's VAS is higher; its t value is 14.851 and its p value is <0.001, statistically significant. When the Lysholm Scores of the two groups were observed and put on a comparison scale, the Supra group's score is higher, with a t value of -2.331 and a p value of 0.027 which is considered statistically significant.

Keywords: Tibial shaft fractures, Infrapatellar, Suprapatellar, Intramedullary nail, Internal fixation, Meta-analysis

Introduction
Tibia and fibula shaft fractures are the most frequently seen cases of long bone fractures. In a population of 100,000 persons, about 45 bone and limb fractures are reported annually. Tibial fractures are linked to a variety of injury mechanisms and severity levels. Between the ages of 19 and 39, highest prevalence of fractures of the tibia and fibula was noted. Tibial fractures have a higher rate of nonunion and malunion than other types of fractures. With 80% of all tibia fractures being tibial diaphysis fractures, they are the most common kind of tibia fracture.
Treatment options for tibial shaft fractures are numerous, depending on the type of soft tissue damage sustained. There is a higher risk of complications in people who have severe open tibia fractures along with a bad forecast for the future. High-energy trauma causes it, which is why young individuals are most frequently affected by it.
Intramedullary nail fixation is still the preferred mode of help for individuals with displaced and nondisplaced fractures of the tibial shafts.
By conforming to the notion of biological osteosynthesis, the gold standard for fixation of tibial shaft fractures has been the intramedullary nailing (IMN) approach for surgical treatment, enabling dynamic stabilization of the fracture with minimally invasive surgery and preservation of the extraosseous blood supply.

Some of the positives that can be observed by using the technique of Intramedullary nailing are Early mobilization, high fusion rates, and minor wound consequences [1, 2].

The standard infrapatellar method for tibia IMN includes flexing or hyper-flexing the knees and introducing the nail via techniques that may opt for a patellar tendon-splitting or patellar tendon-sparing approach. Nevertheless, with the knee in flexion, quadriceps muscle tension frequently induces proximal fracture fragment dislocation, which often leads to situations of valgus and procurvatum [3]. Pain in the anterior region of the knee, which was found to be the most prevalent consequence seen due to the practice of infrapatellar nailing (frequency ranged between 10% to 80%) [4, 5, 6], may slow rehabilitation following tibia IMN.

A suprapatellar procedure in which the knee is to be kept in a semi-extended posture was devised in order to alleviate drawbacks seen as a consequence of infrapatellar nailing.

This method promotes fracture minimization, facilitates radiographic imaging, and eliminates the issues associated with hyperflexion and consequent fragment malalignment [7].

In a recent RCT, suprapatellar IMN insertion was found and listed as better than infrapatellar IMN insertion for treatments of tibial shaft fractures in relation to functional knee results [8].

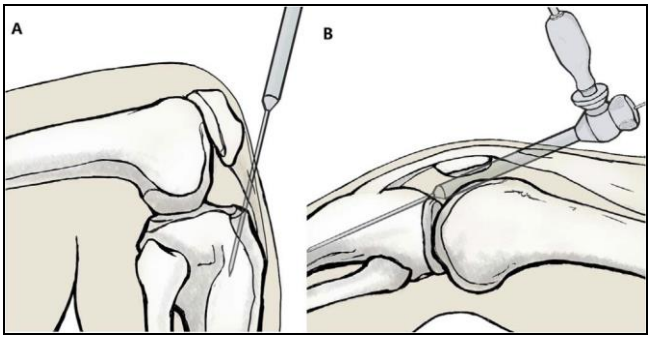

Fig 1: A, Infrapatellar approach; B, Suprapatellar approach."

The requirements for intramedullary nail fixation have been widened by recent developments in nail design and reduction techniques in order to incorporate tibia fractures involving the metaphyseal region, both proximal and distal. In certain fracture types, determining an anatomical beginning point plays an essential role. Recently, suprapatellar nailing in the semi-extended position has been proposed as a reliable surgical method. This approach provides for the formation of a suitable beginning point and enables the minimization of apex anterior deformity fractures in a semi-extended posture.

Numerous studies have compared suprapatellar and infrapatellar intramedullary nailing for the treatment of shaft fractures pertaining to the upper one-third of the tibia.

Suprapatellar approach:

- Shows an improvement in the reduction of fracture and quicker reducibility is observed
- Decreases the likelihood of misalignment during intramedullary nailing of extra-articular upper one-third tibia fractures.
- The knee is placed in 20-degree flexion thus prevents apex anterior angulation of proximal fragment (beaking effect)
- done in the supine position
- This approach also minimizes soft tissue damage and long-term deformity is less
- There is no such study available in Goa.

Hence, we would like to conduct such a study at the only tertiary care hospital in Goa.

Materials and Methods

From the beginning of the database to October 2021, the electronic databases retrieved from Cochrane Library, CNKI, PubMed, Embase, and Wanfang were thoroughly read and searched without linguistic restrictions. Two separate researchers used the terms ("Tibial Fractures" or "Tibia") and ("Fracture Fixation, Intramedullary") and (*patellar) to conduct a systematic review and search for the required information. Additionally, the bibliographies from published original publications and pertinent reviews were evaluated in order to find other researches that were applicable to the study.

- The Department of Orthopaedics will conduct a randomized comparative study over a period of 18 months from Dec 2019 -May 2021.
- Method of sampling - convenience sampling.
- Sample size- 25 each
- Approval from the committee of ethics will be obtained prior to the commencement of the underlying study.
- Written informed consent will be obtained from the patients.

Detailed demographic data and history were obtained from the patient, a clinical examination was done, and investigations and pre-operative radiological images were obtained. Patients received treatment by suprapatellar intramedullary nailing and infrapatellar intramedullary nailing. Post-operative evaluation and radiological images were obtained on 1st post-op day. Patients were followed up weekly for 6 weeks, followed by monthly for 6 months.

Inclusion criteria

- Skeletally mature patients older than 18 years
- Extra Articular upper one-third tibial shaft fractures.
- Closed fractures
- Patient giving consent

Exclusion criteria

- Patients not giving consent.
- Plateau fractures or intra-articular fractures
- Open fractures

Data Analysis

The outcomes were assessed based on- Operative time, Blood loss, Lysholm knee score, Visual analog scale for pain, R.O.M, Time of union, Length of hospital stay, long-term deformity incidences and Radiological results.

The data collected was analyzed using a Microsoft Excel spreadsheet and SPSS software and statistically analyzed using appropriate statistical tests.

Results

In our study there were several parameters analyzed as the following:

Age differences between the two groups are statistically non-significant with a p value of 0.139 and higher in the Infra group with a t value of 1.517.

When the operational times of the two groups are compared, it is evident that the operational times are longer in the infra group, with a t value of 33.061 and a statistically significant p value of <0.001.

When the blood loss (number of mop strokes used) in the two

groups is compared, it is evident that the infra group's blood loss (number of mop strokes used) is higher, with a t value of 8.744 and a p value of <0.001 indicating statistical significance.
When the VAS of the two groups is compared, the infra group's VAS is higher; its t value is 14.851 and its p value is <0.00, which turns out to be statistically significant.
A comparison of the two groups' Lysholm Scores reveals that the Supra group's score is higher, with a t value of -2.331 and a statistically significant p value of 0.027.

Discussion

As far as we are aware, it was the first RCT meta-analysis to assess the clinical and functional results of the knee joint following the insertion of an infrapatellar versus a suprapatellar tibial nail. In comparison to the infrapatellar approach, the suprapatellar method of IMN was linked with a considerable reduction in total bleeding, VAS grades, and fluoroscopy durations, according to the current analysis. Furthermore, there have been substantial differences in Lysholm knee ratings between groups.
The patient's typical operating time was 45 mins in suprapatellar and 75 mins in Infrapatellar. The positional requirements of Infrapatellar include holding the patient's leg in more than 90 degrees flexion. Length of stay is around 48 hrs. post operation in both the techniques. The callus emerged on radiographic evaluation in all patients on average 3-4 weeks following surgery combined with bone healing taking 6-8 weeks.
Long bones frequently suffer from broken tibial shafts, which are usually brought on by high-energy trauma like vehicle accidents or steep falls. Historically, the IMN was regarded as the gold standard for treating tibial shaft fractures due to its favored stable fixation and decreased harm to vascularity and soft tissue. Suprapatellar surgery was a common surgical treatment and did not affect the tendon. Additionally, the nail could be implanted using suprapatellar IMN with the knee extended, protecting the infrapatellar nerve. Reducing perioperative blood loss was a critical issue that may help patients recover faster and require fewer transfusions. According to the current meta-analysis, suprapatellar technique was linked to a considerable reduction in total blood loss.
Patients' comfort and postoperative complications may both benefit from effective pain treatment. The most common complaint after intramedullary nailing surgery was postoperative discomfort, which ranged from mild to severe. It could be caused by a knee structural and nerve injury. In addition, postoperative pain was generated by the surgical stress response, which contained inflammatory components. According to Leliveld and Verhofstad [46], 38 percent of patients who underwent infrapatellar incision experienced chronic knee discomfort as a side effect, and the frequency of iatrogenic infrapatellar nerve injury after IMN was substantial and long-lasting. Postoperative knee discomfort appears to be linked to this nerve damage. A proximal patellar incision was used for the suprapatellar approach, with the intramedullary nail traveling into the trochlear groove.
The suprapatellar technique resulted in a lower incidence of knee discomfort than the infrapatellar approach.
Reduced range of motion following IMN was an unfavorable result that had been well described in studies and was variable [22]. Damage to the vascularity and soft tissue, among other things, might limit range of motion. However, the use of a distinct surgical technique for tibial shaft fractures is still debatable. On long-term follow-up, Leliveld and Verhofstad [46] found that with infrapatellar tibial IMN, the range of mobility in the knee was the same as on the unaffected side. Although Chan *et al*. [9] found that the suprapatellar approach had a better range of motion than the infrapatellar method, the difference was not significant. There was no statistically significant difference in our investigation. It was necessary to conduct long-term follow-up.
In 1982, Lysholm *et al*. produced the first knee scoring scale. It was an eight-item survey about knee function and symptoms that provided a standardized assessment of patient activities of daily living. It's been widely used to treat a variety of knee fractures. In patients having tibial IMN, Song *et al*. [47] discovered a strong link between Lysholm knee scores and knee discomfort. In comparison to infrapatellar groups, suprapatellar groups had better Lysholm knee ratings, according to our findings. Suprapatellar groups had much lower fluoroscopy times. Performing a fluoroscopy during the surgical operation was difficult due to the infrapatellar position. With the knee in a semi-extended position, capturing the orthogonal image of the tibia was easier, and this position may make fracture repair easier.
Nevertheless, there has been no indication that a suprapatellar technique was linked to a reduced amount of patellofemoral joint deterioration. There's still more research to be done in the long term.

Table 1: Descriptive statistics for the patient group

	N	MEAN ± SD	Median (IQR)	Range (Min-Max)
Age	50	26.38±5.38	25(23,29)	19 to 45
Operative time	50	59.3±13.23	57.5(45,73)	43 to 79
Blood Loss (mops used)	50	1.82±0.75	2(1,2)	1 to 3
VAS	50	3.38±1.81	3.5(2,5)	1 to 7
Scores	50	92.7±6.65	95(89,96)	63 to 98

Age

Table 2: Age division of the patients

Age	Age	Valid Percent
<20	3	6
21-30	38	76
31-40	7	14
>40	2	4
Total	50	100

Table 3: Chi square test to compare the categorical variables (Age*Treatment)

Crosstab					
			Treatment		Total
			Infra	Supra	
Age	<20	Count	2	1	3
		% within Treatment	8.0%	4.0%	6.0%
	21-30	Count	16	22	38
		% within Treatment	64.0%	88.0%	76.0%
	31-40	Count	5	2	7
		% within Treatment	20.0%	8.0%	14.0%
	>40	Count	2	0	2
		% within Treatment	8.0%	0.0%	4.0%
Total		Count	25	25	50
		% within Treatment	100.0%	100.0%	100.0%

Chi-Square Tests			
	Value	df	P value (<0.05 is significant)
Pearson Chi-Square	4.566	3	.206

Sex

In our study analysis out of 50 patients, 33 patients 74% are males and 17 patients 26% are females

Table 4: Sex division of the patients

	Sex	Valid Percent
Female	17	34
Male	33	66
Total	50	100

Table 5: Chi square test to compare the categorical variables (Sex * Treatment)

Crosstab					
			Treatment		Total
			Infra	Supra	
Sex	Female	Count	9	8	17
		% within Treatment	36.0%	32.0%	34.0%
	Male	Count	16	17	33
		% within Treatment	64.0%	68.0%	66.0%
Total		Count	25	25	50
		% within Treatment	100.0%	100.0%	100.0%
Chi-Square Tests					
		Value	df	P value (<0.05 is significant)	
Pearson Chi-Square		.089	1	.765	

Mode of Injury

Table 6: Mode of injuries and their division in the patients

	Mode of injury	Valid Percent
RTA	46	92
Sports	4	8
Total	50	100

Table 7: Chi square test to compare the categorical variables (Mode of injury * Treatment)

Crosstab					
			Treatment		Total
			Infra	Supra	
Mode of injury	RTA	Count	21	25	46
		% within Treatment	84.0%	100.0%	92.0%
	Sports	Count	4	0	4
		% within Treatment	16.0%	0.0%	8.0%
Total		Count	25	25	50
		% within Treatment	100.0%	100.0%	100.0%
Chi-Square Tests					
		Value	df	P value (<0.05 is significant)	
Pearson Chi-Square		4.348	1	.037	

Treatment

Table 8: Modes of treatment and their division in the patients

	Treatment	Valid Percent
Infra	25	50
Supra	25	50
Total	50	100

Blood Loss

Table 9: The amount of blood loss measured in terms of mops used, in the patients

	Blood Loss (mops used)	Valid Percent
1	19	38
2	21	42
3	10	20
Total	50	100

Table 10: Chi square test to compare the categorical variables (Blood Loss (mops used) * Treatment)

Crosstab					
			Treatment		Total
			Infra	Supra	
Blood Loss (mops used)	1	Count	0	19	19
		% within Treatment	0.0%	76.0%	38.0%
	2	Count	15	6	21
		% within Treatment	60.0%	24.0%	42.0%
	3	Count	10	0	10
		% within Treatment	40.0%	0.0%	20.0%
Total		Count	25	25	50
		% within Treatment	100.0%	100.0%	100.0%
Chi-Square Tests					
		Value	df	P value (<0.05 is significant)	
Pearson Chi-Square		32.857	2	<0.001	

Range of Movement

Table 11: The Ranges of Movement and their division as observed in the patients

	R.O.M	Valid Percent
0-120	3	6
0-130	36	72
10-120	6	12
10-130	5	10
Total	50	100

Table 12: Chi square test to compare the categorical variables (R.O.M * Treatment)

Crosstab					
			Treatment		Total
			Infra	Supra	
R.O.M	0-120	Count	2	1	3
		% within Treatment	8.0%	4.0%	6.0%
	0-130	Count	12	24	36
		% within Treatment	48.0%	96.0%	72.0%
	10-120	Count	6	0	6
		% within Treatment	24.0%	0.0%	12.0%
	10-130	Count	5	0	5
		% within Treatment	20.0%	0.0%	10.0%
Total		Count	25	25	50
		% within Treatment	100.0%	100.0%	100.0%
Chi-Square Tests					
		Value	df	P value (<0.05 is significant)	
Pearson Chi-Square		15.333	3	.002	

VAS

Table 13: The VAS and its division as observed in the patients

	VAS	Valid Percent
1	10	20
2	11	22
3	4	8
4	7	14
5	12	24
6	5	10
7	1	2
Total	50	100

Table 14: Chi square test to compare the categorical variables (VAS * Treatment)

Crosstab					
			Treatment		Total
			Infra	Supra	
VAS	1	Count	0	10	10
		% within Treatment	0.0%	40.0%	20.0%
	2	Count	0	11	11
		% within Treatment	0.0%	44.0%	22.0%
	3	Count	0	4	4
		% within Treatment	0.0%	16.0%	8.0%
	4	Count	7	0	7
		% within Treatment	28.0%	0.0%	14.0%
	5	Count	12	0	12
		% within Treatment	48.0%	0.0%	24.0%
	6	Count	5	0	5
		% within Treatment	20.0%	0.0%	10.0%
	7	Count	1	0	1
		% within Treatment	4.0%	0.0%	2.0%
Total		Count	25	25	50
		% within Treatment	100.0%	100.0%	100.0%

Chi-Square Tests			
	Value	df	P value (<0.05 is significant)
Pearson Chi-Square	50<0.001	6	<0.001

The Lysholm & Gillquist Knee Scoring Scale

In our study analysis out of 50 patients, 36 (72%) patients had excellent score, 11 (22%) patients had good score, 2 (4%) patients had fair scores; 1 (2%) patient had poor scores.

Table 15: Lysholm knee scores and their division in the patients

	Lysholm knee score	Valid Percent
E	36	72
F	2	4
G	11	22
P	1	2
Total	50	100

Table 16: Chi square test to compare the categorical variables (Lysholm knee score * Treatment)

Crosstab					
			Treatment		Total
			Infra	Supra	
Lysholm knee score	E	Count	14	22	36
		% within Treatment	56.0%	88.0%	72.0%
	F	Count	2	0	2
		% within Treatment	8.0%	0.0%	4.0%
	G	Count	8	3	11
		% within Treatment	32.0%	12.0%	22.0%
	P	Count	1	0	1
		% within Treatment	4.0%	0.0%	2.0%
Total		Count	25	25	50
		% within Treatment	100.0%	100.0%	100.0%

Chi-Square Tests			
	Value	df	P value (<0.05 is significant)
Pearson Chi-Square	7.051	3	.070

Union at 6 Months

Table 17: The incidences of Union at 6 months and their division as observed in the patients

	Union at 6 months	Valid Percent
Complete	46	92
Incomplete	4	8
Total	50	100

Table 18: Chi square test to compare the categorical variables (Union at 6 months * Treatment)

Crosstab					
			Treatment		Total
			Infra	Supra	
Union at 6 months	Complete	Count	22	24	46
		% within Treatment	88.0%	96.0%	92.0%
	Incomplete	Count	3	1	4
		% within Treatment	12.0%	4.0%	8.0%
Total		Count	25	25	50
		% within Treatment	100.0%	100.0%	100.0%

Chi-Square Tests			
	Value	df	P value (<0.05 is significant)
Pearson Chi-Square	1.087	1	.297

Table 19: Independent t test to compare the continuous variables

	Infra(n=25)	Supra(n=25)	t	P Value
	MEAN ± SD	Mean ± SD		
Age	27.52±6.91	25.24±2.96	1.517	0.139
Operative time	72.12±3.21	46.48±2.18	33.061	<0.001
Blood Loss (mops used)	2.4±0.5	1.24±0.44	8.744	<0.001
VAS	5±0.82	1.76±0.72	14.851	<0.001
Lysholm Scores	90.6±8.63	94.8±2.6	-2.331	0.027

Conclusion

The results of suprapatellar intramedullary nailing in terms of functionality for upper one-third shaft of tibia fractures in comparison with infrapatellar approach were studied and an evaluation of the long-term deformity incidences in both the above approaches was done at the Department of Orthopedics over a period of 18 months from Dec 2019 - May 2021.

The outcomes were assessed based on- Operative time, Blood loss, Lysholm knee score, Visual analog scale for pain, R.O.M, Time of union, Length of hospital stay, long term deformity incidences and Radiological results keeping the inclusion criteria in mind.

The conventional treatment adopted in cases of displaced tibial shaft fractures is reamed locked intramedullary nailing. A proper beginning point is still an important aspect of every surgical treatment. In a semi-extended position of the knee, a suprapatellar approach of intramedullary tibial nailing offers an alternative to the typical infrapatellar method. The use of specialized instrumentation and a canula system enables for safe nail insertion while reducing the potential of iatrogenic injury to intra articular tissues. In proximal third tibial fractures and all diaphyseal tibial fractures, the semi extended position of the knee aids fracture reduction. According to preliminary findings, there was a low rate of postoperative anterior knee pain.

Fractures awaiting infrapatellar nailing due to poor skin condition have high risk of going into compartment syndrome could be operated early due to suprapatellar approach and could go early mobilization.

A key advantage of the suprapatellar method, which proved particularly successful in the management of challenging metaphyseal and diaphyseal tibia fractures, was the ability to extend the knee during surgery. By matching the starting point with the medullary canal, the suprapatellar technique reduces the risk of posterior cortex perforation in proximal oblique metaphyseal fractures with posterior cortical extension. In addition, by calming the quadriceps muscle, it reduces malreduction. This method also aids in the reduction of Varus and Valgus deformities by using the femoral trochlear groove as a reference to the starting point. This keeps the lower extremity's mechanical axis in place. Additionally, the surgeon can assess through the tibial plateau's safe zone.

In comparison to the infrapatellar technique, suprapatellar intramedullary nailing could dramatically minimize total loss of blood, postoperative knee problems, and fluoroscopy durations. Furthermore, it was linked to a reduction in Lysholm knee scores and has a lesser duration of operating time.

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Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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