DOI: 10.7860/JCDR/2022/57214.17202

Original Article

Orthopaedics Section

Intramedullary Nail Supplemented with Poller Screws for Proximal and Distal 1/3rd Shaft Tibial Fracture: A Prospective Interventional Study from North India

GIRISH SAHNI[1], HARISH BANSAL[2], ASHISH GARG[3], AKASHDEEP SINGH[4], ASHISH KAVIA[5], HARI OM AGGARWAL[6]

ABSTRACT

Introduction: The fracture of shaft of the tibia is the most common long bone fracture. The treatment goal for shaft tibial fracture is to achieve union with correction of both axial and rotational alignment and, maintain initial fracture length. Higher malunion rates are seen in fractures of the proximal and distal 1/3rd of the shaft of the tibia. However, Intramedullary (IM) nailing is the preferred choice of operative management of diaphyseal fractures of the lower limb.

Aim: To evaluate the functional and radiological outcomes of IM nail supplemented with Poller screws for proximal and distal 1/3rd shaft tibial fractures.

Materials and Methods: A prospective, interventional study was conducted in the Government Medical College, Patiala, Punjab, India from May 2020 to November 2021. A total of 30 fracture patients in the age group of 18 to 60 years were included in the study. All the subjects were treated with IM nail supplemented with Poller screws for proximal and distal 1/3rd shaft tibial fractures. Twenty cases were closed fractures and 10 were open (grade I or II according to Gustilo Anderson's classification of compound tibia fracture). Patients were followed-up at 3 weeks, then 6 weekly till union. Patients were evaluated by Karlström-Olerud's functional evaluation criteria.The data was statistically analysed using IBM Statistical Package for the Social Sciences (SPSS) software version 23.0.

Results: The mean time of fracture union was 17.33±2.59 weeks with a maximum (n=19) patients in ≤15 weeks, followed by 15-20 weeks (n=10) and only one patient had delayed union (>20 weeks). According to Karlström-Olerud's functional evaluation scale 18 (60%) patients had excellent outcome followed by good outcome in 8 (26.7%) patients, while 2 (6.7%) patients had satisfactory and 2 (6.7%) patients moderate outcomes. The total mean varus/valgus deformity preoperatively was 10.17±4.15° while postoperatively it was 1.63±2.3°. The total mean antecurvatum/recurvatum deformity preoperatively was 6.47±5.906° while postoperatively it was 0.20±0.61°. Postoperative complications were observed such as shortening of the leg (n=2), movement loss in the ankle (n=4), movement loss in the knees (n=3), muscle wasting (n=6) and subtalar movement loss (n=6). One patient had a superficial skin infection (oozing of purulent discharge from distal locking skin suture site), which was treated with prolonged antibiotics.

Conclusion: Poller screws were found to be effective in achieving fracture alignment and hence, serve as a effective fracture reduction tool. Also helps to maintain the fracture aligned until it healed, preventing the loss of the initial reduction.

Keywords: Antecurvatum, Gustilo anderson classification, Karlström-olerud's functional evaluation scale, Recurvatum

INTRODUCTION

The fracture of shaft of the tibia is the most common fracture and is seen in nearly 4% of the old population. Both low and high energy mechanisms are involved in causing these fractures [1]. The aim of the treatment for the shaft of tibia fracture is to achieve union with correction of both axial and rotational alignment and to maintain initial fracture length. Early mobilisation of the patient along with pain free weight bearing and functional range of movement of the knee and ankle joints are also advocated [2-5]. Proximal tibia fractures are defined as, those extending from the articular surface up to 1.5 times, the medial to the lateral width of the articular surface, and most commonly occur due to high velocity trauma. Operative management is preferred, as in conservative management, there is a risk of malunion, non union or joint stiffness. Fractures of the proximal and distal one-thirds of the tibial shaft have remained a challenge and higher malunion rates were observed [6].

Non articular fractures of the proximal third of the tibia account for 5-11% of tibial shaft injuries [1]. These fractures frequently, result in malunion with apex anterior and valgus deformities. Similarly, displaced extra-articular fractures of the distal tibia are difficult to treat, with residual varus, valgus, recurvatum, or procurvatum. The small size of the distal fragment can make both, maintaining the reduction and placing adequate distal locking fixation difficult, with the centre-centre placement of the nail in both the proximal and distal fragments being critical [1].

The goals of surgical management include correction, and maintenance of sagittal and coronal alignment, the establishment of length and rotation, and early functional range of movements of the knee and ankle. However, Intramedullary (IM) nailing is the preferred choice for operative management of diaphyseal fractures of the lower limb and is also a part of the armamentarium for the treatment of metaphyseal fractures. Nailing of metaphyseal fractures with a short distal fragment is associated with an increase in malalignment particularly in the coronal plane, non union, and the need for secondary procedures to achieve union. There are limitations with the 'standard' practice of IM nailing in the treatment of metaphyseal fractures, owing to the long lever arm, metaphyseal enlargement, and epiphyseal-metaphyseal fixation problems, which make the reduction and controlling angulation of the shorter bone fragment technically difficult. This may be attributed to an inaccurate entry site or both displacing muscular forces and residual instability [7].

To improve the fixation of the nail, in metaphyseal fractures various techniques have been recommended; including percutaneous

reduction clamps, fibular plating, temporary unicortical plating, and blocking screws (Poller screw).

To prevent axial deformities in proximal or distal third tibia fractures during IM nailing, the "Poller screw" was firstly described by Krettek in 1999, which was similar to the metal devices designed to block or guide traffic. The Poller screw acts by reduction of the width of the medullary canal in the metaphyseal area and thus, by providing a tight fitting for the intramedullary nail. Therefore, it increases the stability of the bone-implant construct [7-9]. A high degree of axial malalignment was seen in the proximal and distal third tibial shaft fracture of the metaphyseal region, which was stabilised with locking intramedullary nails along with Poller screws. The cause of this was muscular forces which displace the fracture and causes instability [10]. As there is a paucity of articles comparing the clinical usefulness of Poller screw augmentation against that of IM nail alone for the treatment of long bone fractures. Therefore, the aim of the present study was to evaluate the outcome of IM nailing supplemented with Poller screws for proximal and distal 1/3rd shaft tibial fractures.

MATERIALS AND METHODS

The present prospective, interventional study was conducted in the Department of Orthopaedics, Rajindra Hospital, Government Medical College, Patiala, Punjab, India from May 2020 to November 2021 after taking the ethical clearance from Institutional Research Ethics Committee vide letter number (317\2020). Informed consent was obtained from the study participants.

A total of 20 males and 10 females (total 30 fractures) in the age group between 18 to 60 years, who had undergone IM nailing with Poller screws augmentation for proximal and distal 1/3rd shaft tibial fractures form the sample population. Most (n=20) of the patients had closed fractures and 10 patients had open fractures.

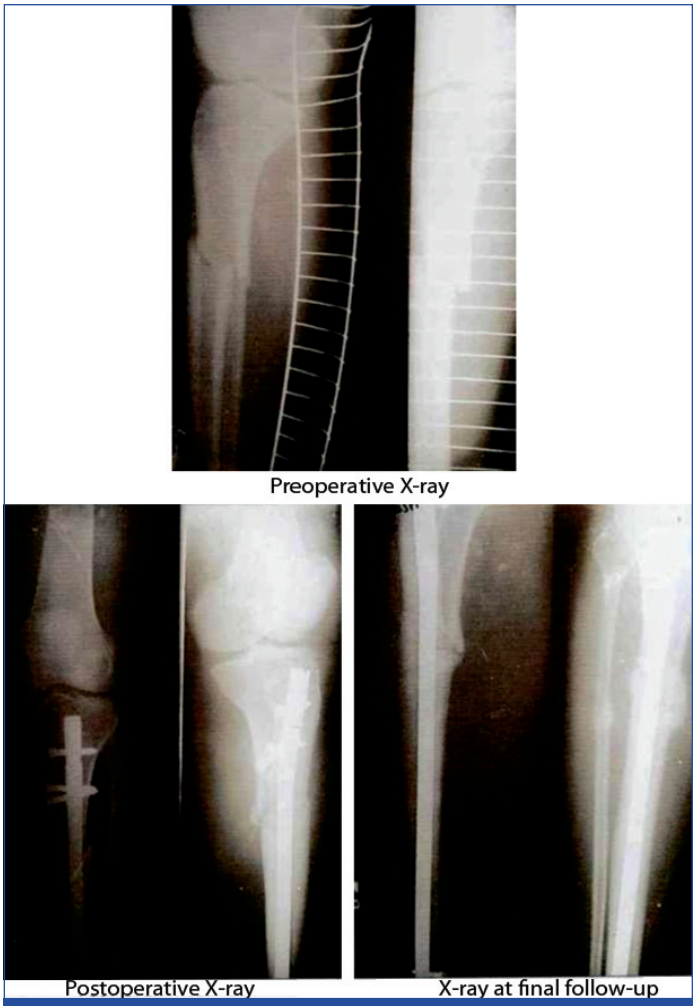
Inclusion criteria: Patients between age group between 18 to 60 years who have closed fractures of both bone legs or have open fractures in proximal 1/3rd and distal 1/3rd shaft tibia according to Gustilo Anderson classification 2 [1] were included in the study.

Exclusion criteria: Patients with the proximal tibial fractured fragment, less than 7 cm, with proximal and distal tibial intra-articular fracture line, within displaced fractures were excluded. Patients with any haematological disorder like thrombocytopenia and patients with open fractures of both bone leg according to Gustilo Anderson classification 3A, 3B and 3C and extensively comminuted fractures were excluded from the study.

Study Procedure

Intraoperatively, on a well-padded knee rest, the knee was kept in a semi-extended position. Poller screw was fixed on the opposite side to the apex of deformity, along the concave border in both Anteroposterior (AP) and lateral views under fluoroscopic guidance. After patellar tendon retraction at midline, by bone awl; a high entry point was made. The guided wire was passed to the centre, position was checked fluoroscopically on AP and lateral views, then sequential reaming was done. Reamed nail of appropriate length and diameter was inserted slowly while negotiating with the Poller screws. Locking of the nail was done both proximally and distally. Poller screws were retained [Table/Fig-1].

Postoperatively, patients were mobilised on postoperative day one of surgery. Physical therapy in the form of static and dynamic quadriceps exercises were given. For six to eight weeks partial weight-bearing (15 to 20 kg) was allowed. Then, weight-bearing was increased, depending on the radiographic evidence of bone union and the absence of pain. The first follow-up was done on 21st day, then each follow-up was done for every six weeks until the union was achieved. Patients were evaluated by Karlström-Olerud's functional evaluation criteria [Table/Fig-2] [11,12].



[Table/Fig-1]: Preoperative and postoperative tibial fracture radiographs.

Parameter	3 points	2 points	1 point
Pain	None	Slight	Severe
Difficulty in walking	None	Moderate	Severe limping
Difficulty in climbing stairs	None	With help	Unable
Difficulty in the sports activity	None	Some sports	Unable
Occupational limitation	None	Moderate	Unable
Skin	Normal	Different color	Ulcer/fistula
Deformity	None	Mild	Significant
Varus/valgus	0	1-5	>5
Ante/recurvatum	0	1-3	>3
Muscleatrophy (cm)	<1	1-2	>2
Shortening of the leg (cm)	<1	1-2	>2
Movement loss in the knee (°)	<10	10-20	>20
Movement loss in the ankle (°)	<10	10-20	>20
Subtalar movement loss (°)	<10	10-20	>20

[Table/Fig-2]: Karlström-Olerud's scoring criteria [11,12].

Points were given and added up based on the above criteria as below scores:

36 points: excellent

35-33 points: good

32-30 points: satisfactory

29-27 points: moderate

26-24 points: poor

Alignment and deformity were calculated from postoperative X-ray and the degree of varus/valgus, and antecurvatum/recurvatum malalignment were then calculated. Varus and antecurvatum angulation were symbolised as positive (+) values. Valgus and recurvatum were symbolised as negative (-) values.

STATISTICAL ANALYSIS

The data was entered in the form of a data matrix in Microsoft Excel® and statistically analysed using IBM Statistical Package for the Social Sciences (SPSS) software version 23.0. Paired t-test were used for comparing mean values.

RESULTS

Male predominance was observed in this study with 20 (66.7%) males and 10 (33.3%) females. It was observed that 40% of patients were in the age group 41-50 years. The mean age of the patients was 39.36±9.9 years [Table/Fig-3].

Age group (years)	Male n (%)	Female n (%)
10-20	0	0
21-30	6 (30)	2 (20)
31-40	5 (25)	2 (20)
41-50	8 (40)	4 (40)
51-60	1 (5)	2 (20)
61-70	0	0
Mean Age±SD	39.36±9.9	

[Table/Fig-3]: Age wise and gender wise distribution of subjects.

In all the patients, the closed reduction technique was done. Among 30 cases, 18 cases needed one additional Poller screw to correct the existing deformity. The mean time for fracture union was 17.33±2.59 weeks with 19 patients presenting in between range ≤15 weeks, followed by 10 patients in 16-20 weeks and only one patient had delayed union >20 weeks. About 60% of patients (n=18) in the present study had excellent outcomes, followed by good outcome was seen in 8 (26.7%) patients, 2 (6.7%) patients each had satisfactory and moderate outcome according to KARLSTRÖM-OLERUD'S FUNCTIONAL EVALUATION.

Residual mean varus alignment postoperatively was +1.47° when compared to the preoperative mean value of +9.06°. Residual mean valgus malalignment postoperatively was -1.85° when compared to the preoperative mean value of -11.62° [Table/Fig-4].

Deformity	Time	N	Mean	SD	t-test	p-value*
Varus deformity	Preoperatively	17	9.06	4.366	7.643	0.001
	Postoperatively	17	1.47	2.401		
Valgus deformity	Preoperatively	13	11.62	3.501	8.988	0.001
	Postoperatively	13	1.85	2.41		

[Table/Fig-4]: Preoperative and postoperative comparison of mean angulation of varus and valgus deformities.
*p-value <0.05 was considered statistically significant

The total mean varus/valgus deformity preoperatively was 10.17±4.15° while postoperatively it was 1.63±2.3°. Statistically, a significant difference was observed between the two (p-value <0.05) [Table/Fig-5]. In the present study, five patients had varus and valgus >5°, and 25 patients had <5° after surgery.

Deformity	Time	N	Mean	SD	t- test	p-value*
Varus/ valgus	Preoperatively	30	10.17°	4.153	11.400	0.001
	Postoperatively	30	1.63°	2.371		
	At union	30	1.63°	2.371		

[Table/Fig-5]: Comparison of mean angulation of varus/valgus deformities (combined) preoperatively and postoperatively.
*p-value <0.05 was considered statistically significant

Postoperative mean antecurvatum angulation was +0.12° when compared to the preoperative mean value of +5.71°. Postoperative mean recurvatum angulation was -0.31° when compared to the preoperative mean value of -7.77° [Table/Fig-6].

The total mean antecurvatum/recurvatum deformity preoperatively was 6.47±5.9°, while postoperatively it was 0.20±.61° [Table/Fig-7].

Deformity	Time	N	Mean	SD	t-test	p-value*
Antecurvatum (positive)	Preoperatively	17	5.71	5.169	4.403	0.001
	Postoperatively	17	0.12	0.485		
	At union	17	0.12	0.485		
Recurvatum (negative)	Preoperatively	13	7.77	7.507	3.451	0.005
	Postoperatively	13	0.31	0.751		
	At union	13	0.31	0.751		

[Table/Fig-6]: Measurement of antecurvatum and recurvatum deformities.
*p-value <0.05 was considered statistically significant

Deformity	Time	N	Mean	SD	t-test	p-value
Antecurvatum/ recurvatum Deformity	Preoperatively	13	6.47°	5.906	5.656	0.001
	Postoperatively	13	0.20°	0.610		
	At union	13	0.20°	0.610		

[Table/Fig-7]: Comparison of total antecurvatum/recurvatum deformities (combined) preoperatively and postoperatively.
*p-value <0.05 was considered statistically significant

Postoperative complications included shortening of the leg, two patients had 0.5 cm shortening, four patients had 10° loss in ankle dorsiflexion and three patients lost movement in knees (two patients with 20° Flexion and one with 15° flexion loss, and six patients there was subtalar movement loss (two patients with 10° inversion loss, three patients with 5° inversion loss, and one patient with 5° eversion loss) and one patient had oozing of purulent discharge from distal locking skin suture site, which was treated with washing and prolonged antibiotics [Table/Fig-8].

Complication	Present	Percentage
Shortening of leg	2	6.6%
Movement loss in the knee (in degree)	3	10%
Movement loss in the Ankle	4	13.33%
Muscle wasting	6	20%
Subtalar movement loss	6	20%

[Table/Fig-8]: Postoperative complications of the procedure.

DISCUSSION

Male predominance was observed in the present study with 66.7% males and 33.3% females. The mean age of the patients in the present study was 39.36±9.9 years. In a study by Kulkarni SG et al., also male predominance was observed with 71.4% of patients being male [13]. Kumar A et al., 2020 showed M:F ratioto be 83.3%, with males to be five times more than females [14]. Hussain T et al., in 2020 showed 57.1% of patients with tibial shaft fractures to be male [15].

Most of the patients i.e. 66.7% had closed fractures. Kumar A et al., in their study showed the prevalence of grade I and II fractures [14]. A total of 10 ten patients were in grade I and II combined in the present study. In this study, 17 cases were of valgus while 13 were varus. The range of varus to valgus malalignment varies from +14 to -20° preoperatively and it changed to +8 to -7° postoperatively with only five (16.6%)cases having >5° postoperatively. In a study by Kulkarni SG et al., preoperatively, of the total 75 cases, 30 were varus, 10 were neutraland 35 were valgus [13]. The range of varus to valgus varies from +24 to -11°. Postoperatively, most of the cases i.e 74 had less than 5° of varus or valgus deformity, and only one case developed a varus malalignment of +7°. In another similar study by Kumar A et al., postoperatively, three patients had >5° varus deformity and 10 patients had <5°valgus deformity with only one patient being >7° [14]. In the present study, five patients had varus and valgus >5°, and 25 patients had <5° after surgery.

According to the [Table/Fig-9], in a study by Kulkarni SG et al., antecurvatum to recurvatum deformity range was +8 to -17° [13]. Postoperative, cases had 0° deformity in 65 cases, seven had a deformity of <3°, and three patients had a deformity of 4-9°.

Of the 75 cases preoperatively, 28 cases had recurvatum, 40 had procurvatum, and 17 had 0° deformity. In the present study, antecurvatum to recurvatum deformity range varies from +18 to -24°. Postoperatively, none of the patients had deformity >3°. The results of the study by Kulkarni SG et al., were similar to the present study [13]. In a study by Hussain T et al., postoperatively 32 cases had 0°, two had a 0-3° and one had 4° similar to the present study [15].

	Antecurvatum(+)/recurvatum(-) deformity			
	Preoperative	Postoperatively		
Study	Range	0	0-3	>3
Present study	+18 to -24°	90%	10%	0%
Kulkarni SG et al., [13]	+8 to -17°	86.7%	9.3%	4%
Hussain T et al., [15]	+7 to -16°.	91.4%	5.8%	2.8%

[Table/Fig-9]: Antecurvatum/recurvatum deformity [13,15].

In the present study, shortening of the leg was observed in 6.6% of patients, 13.33% and 10% observed, movement loss in the ankle and knee respectively, while muscle wasting and subtalar movement loss were observed in 20% each. One patient had a superficial skin infection (oozing of purulent discharge from distal locking skin suture site) treated with prolonged antibiotics. In a study by Bhangadiya R related to Poller screw, no complication was noticed [16]. In 30 cases after the radiographic union of bone, nail, and screw removal was done. Full quadriceps strength, with no flexion deformity and ligamentous instability, was experienced in all cases. In postoperative complications, five patients had pain in the anterior knee joint and two patients had superficial infections, which were treated with debridement of local tissue and by inserting antibiotic-impregnated beads. Kulkarni SG et al., reported anterior knee joint pain in eight patients and superficial infections in four patients, as a postoperative complication, which was managed by debridement locally and by inserting antibiotic-impregnated beads [13]. As compared to IM nailing alone, Guo J et al., reported non union in 0%, malunion in 3%, and need for secondary surgical procedures only in 3% of cases and they also experienced shorter fracture healing time by augmenting IM nail with Poller screws [17].

All the patients completed the study and the functional evaluation criteria by Karlström-Olerud for measuring the functional outcome yielded results that were in favor of the results for radiological and clinical signs of union.

Limitation(s)

However, the sample size was small; therefore, within the limitations of the study, future research with larger sample size is recommended to further ascertain the findings of the index study.

CONCLUSION(S)

Poller screws used with IM nailing help in achieving fracture alignment by functionally decreasing the medullary width and by improving bone-implant construct stability. It also keeps the fracture aligned until it is healed, preventing the loss of the initial reduction. So from the present study, it is suggested that that pollar screws can be used in proximal 1/3rd and distal 1/3rd of shaft tibial fractures for achieving better fracture alignment.

REFERENCES

[1] Thompson JH, Koutsogiannis P, Jahangir A. Tibia Fractures Overview. In: StatPearls. StatPearls Publishing, Treasure Island (FL); 2021. PMID: 30020639.
[2] Freedman EL, Johnson EE. Radiographic analysis of tibial fracture malalignment following intramedullary nailing. Clinical orthopaedics and related research. 1995;(315):25-33.
[3] Ahlers J, Von Issendorff WD. Incidence and causes of malalignment following tibial intramedullary nailing. Unfallchirurgie. 1992;18(1):31-36.
[4] Henley MB, Meier M, Tencer AF. Influences of some design parameters on the biomechanics of the unreamed tibial intramedullary nail. Journal of orthopaedic trauma. 1993;7(4):311-19.
[5] Tornetta P, Collins E. Semiextended position for intramedullary nailing of the proximal tibia. Clinical Orthopaedics and Related Research®. 1996;328:185-89.
[6] Wysocki RW, Kapotas JS, Virkus WW. Intramedullary nailing of proximal and distal one-third tibial shaft fractures with intraoperative two-pin external fixation. Journal of Trauma and Acute Care Surgery. 2009;66(4):1135-39.
[7] Krettek C, Stephan C, Schandelmaier P, Richter M, Pape HC, Miclau T, et al. The use of Poller screws as blocking screws in stabilising tibial fractures treated with small diameter intramedullary nails. The Journal of Bone and Joint Surgery. British volume. 1999;81(6):963-68.
[8] Tennyson M, Krkovic M, Fortune M, Abdulkarim A. Systematic review on the outcomes of poller screw augmentation in intramedullary nailing of long bone fracture. EFORT open reviews. 2020;5(3):189-03.
[9] Kumar A, Panda KK, Singh A, Singh AK. Intramedullary Interlocked Nail with Poller Screw Guidance for management of Extra-articular Proximal Tibial Fractures: A Prospective Study. Int J Cur Res Rev| Vol. 2020;12(18):95.
[10] Seyhan M, Kocaoglu B, Gereli A, Nalbantoglu U, Turkmen M. Treatment for distal tibial fractures with intramedullary nails and blocking screws. European Journal of Orthopaedic Surgery & Traumatology. 2012;22(5):395-01.
[11] Dr. Bandaru Balakrishna, Dr. VV Vinay Vivek, Dr. K Satya Kumar. Role of various modalities in the management of compound grade 3A and 3B fractures of tibia. Int J Orthop Sci. 2019;5(3):131-37. Doi: 10.22271/ortho.2019.v5.i3c.1518
[12] Al-Toukhy ZM, Abdel-AAl MA. Fractures of the Proximal Third Tibia Treated With Intramedullary Interlocking Nails and Blocking Screws. International Journal of Orthopaedics. 2016;3(5):636-41.
[13] Kulkarni SG, Varshneya A, Kulkarni S, Kulkarni GS, Kulkarni MG, Kulkarni VS, et al. Intramedullary nailing supplemented with Poller screws for proximal tibial fractures. Journal of Orthopaedic Surgery. 2012;20(3):307-11.
[14] Kumar A, Panda KK, Singh A, Singh AK. Intramedullary Interlocked Nail with Poller Screw Guidance for management of Extra-articular Proximal Tibial Fractures: A Prospective Study. Int J Cur Res Rev| Vol. 2020;12(18):95.
[15] Hussain SA, Kalaiah K, Kumar B. Functional outcome of proximal third tibial fractures with intramedullary tibial locking nail and poller screws. International Journal of Orthopaedics. 2020;6(1):373-75.
[16] Bhangadiya R. An outcome analysis to determine the uses of poller screw in treatment of displaced proximal and distal shaft metadiaphyseal fractures of tibia treated with intramedullary nailing. Ortho Rheum Open Access J. 2016;2(2):01-04.
[17] Guo J, Zha J, Di J, Yin Y, Hou Z, Zhang Y, et al. Outcome Analysis of Intramedullary Nailing Augmented with Poller Screws for Treating Difficult Reduction Fractures of Femur and Tibia: A Retrospective Cohort Study. Biomed Res Int. 2021;2021:6615776.

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. Senior Resident, Department of Orthopaedics, All India Institute of Medical Sciences, Jodhpur, Rajasthan, India.
4. Senior Resident, Department of Orthopaedics, Government Medical College, Patiala, Punjab, India.
5. Assistant Professor, Department of Physical Medicine and Rehabilitation, Government Medical College, Patiala, Punjab, India.
6. Professor, Department of Orthopaedics, Government Medical College, Patiala, Punjab, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. Hari Om Aggarwal,
H. No. 34, Dhaliwal Colony, Patiala, Punjab, India.
E-mail: drhariom62@gmail.com

PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Apr 23, 2022
- Manual Googling: Sep 01, 2022
- iThenticate Software: Sep 08, 2022 (20%)

ETYMOLOGY: Author Origin

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. Yes

Date of Submission: **Apr 20, 2022**
Date of Peer Review: **May 28, 2022**
Date of Acceptance: **Sep 08, 2022**
Date of Publishing: **Dec 01, 2022**