

Tibial Tuberosity Fixation in Complex Proximal Tibia Fractures using Thin Profile Distal Fibular Plate: A Prospective Study with 12-month Outcomes

NITESH KUMAR RATHI¹, NAVEEN SATHIYASEELAN², J BENJAMIN VINODH³,
ARUN VIGNESH⁴, ILAVARASAN M DHAMU⁵



ABSTRACT

Introduction: Proximal tibial plateau fractures are common intra-articular injuries that result from either direct axial compressive trauma or indirect coronal trauma. The standard fixation method is bi-columnar dual plating. In cases with additional tibial tuberosity fractures, a thin-profile distal fibular plate can be used for repair.

Aim: To assess the clinical outcomes of a combined posteromedial, anterolateral, and thin distal fibular plating of the tibial tuberosity fractures, and also to assess the radiological outcome in complex proximal tibia Schatzker type 5 and 6 fractures with additional tibial tuberosity fractures.

Materials and Methods: This prospective study was carried out at the Orthopaedics Department of Saveetha Institute of Medical and Technical Sciences, Chennai, Tamil Nadu, India from January 2017 to January 2022, on 18 patients with tibial plateau fractures (Schatzker type V or VI) associated with tibial tuberosity avulsion fractures. These fractures were fixed with thin-profile distal fibular plates. The functional outcome of the

knee joint was assessed after one year, using the Knee Society score. Descriptive statistics were used to compute means, Standard Deviations, and ranges. Student's t-tests and One-way Analysis of Variance (ANOVA) were used to compare the means. The p-value of ≤ 0.05 was considered statistically significant.

Results: The average age of the study population was 39.4 ± 5.6 years. Road traffic accidents were the most frequent mode of injury in 14 (77%) individuals. No perioperative complications were noted. The average duration of surgery was 114 ± 10.4 minutes, and the average blood loss was 146 ± 40 mL, throughout the procedure. The Knee Society score at 12 months postoperatively was excellent at 93.6 (range 92 to 98). Radiographic bone union was observed after an average of 12.4 weeks.

Conclusion: Multiplanar complicated proximal tibia Schatzker type V and VI fractures with tibial tuberosity avulsion fractures may be effectively treated using a novel technique of thin-profile distal fibular plating. The bi-columnar plates combined with open reduction and internal fixation through two incisions with thin distal fibular plates showed satisfactory results.

Keywords: Dual column plating, Knee society score, Tibial tuberosity fractures

INTRODUCTION

Tibial plateau fractures account for 1% of all fractures and exhibit a bimodal distribution, with a peak occurrence in young patients due to motor vehicle crashes or bumper strike injuries resulting in proximal tibial intra-articular fractures. These fractures can also be seen in elderly patients with osteoporotic bones who experience less severe trauma [1,2].

One of the most typical intra-articular fractures is the proximal tibial plateau fracture, which can result from either direct trauma in an axial compressive pattern or indirect trauma in a coronal fracture pattern [3]. These fracture patterns are very complex and may impact either the medial or lateral tibial plateaus, or even both. Understanding the type of injury, such as ligament injuries, meniscal tears, and high or low-energy trauma, can facilitate the course of therapy for these fractures [3].

The clinical management of complicated tibial plateau fractures still remains a challenge. These fractures are commonly referred to as C-type injuries when using the Arbeitsgemeinschaft für Osteosynthesefragen (AO) classification [4] or as type V and VI when using the Schatzker classification [5]. High-energy fractures of the type V and VI Schatzker types are frequently associated with additional local and systemic damage. High-energy tibial plateau fractures can be treated with a variety of techniques, such as intramedullary nailing [6], dual plating [7], and definitive external fixation [8], although the most effective course of care is still up for

debate. Multiple surgical techniques and fracture fixation methods have been devised to treat these fractures. The open reduction and internal fixation procedures for each tibial plateau help in preserving anatomic articular congruity, restoring mechanical alignment, and enabling early knee joint mobilisation. These open reduction and internal fixation procedures, particularly when carried out through damaged soft-tissues, have occasionally been linked to serious wound complications [9].

Every fracture is unique in its shape and requires individualised care. Tibial plateau fractures are often treated using two-dimensional classification methods. Several authors have suggested that treating tibial plateau fractures requires considering the fracture in three dimensions using Computed Tomography (CT) [10,11]. The standard recommendation for the definitive fixation of this type of fracture is bi-columnar dual plating [12-15]. However, there are situations in which, in addition to fractures of the tibial condyles, a thin-profile distal fibular plate was employed for repairing the tibial tuberosity avulsion fractures [16].

The present study used a thin, contoured fibular plate for the tibial tuberosity to minimise hardware prominence. The optimal placement is directly anterior over the tibial tuberosity. Soft-tissue is dissected medially to visualise the patellar tendon and distally to its insertion at the tibial tuberosity through anteromedial or anterolateral incisions for bicondylar fracture fixation. The present study aimed to evaluate the clinical outcomes as well as the radiological results

of bi-columnar plating combined with additional thin distal fibular plating for the tibial tuberosity in complex proximal tibia Schatzker type 5 and 6 fractures with additional tibial tuberosity fractures.

MATERIALS AND METHODS

The prospective study was conducted at the Orthopaedics Department of Saveetha Institute of Medical and Technical Sciences (SIMATS), Chennai, Tamil Nadu, India, from January 2017 to January 2022 on 18 patients after obtaining approval from the Ethics Committee (117/06/2022/IEC/SMCH). The informed consent was obtained from the patients.

Inclusion and Exclusion criteria: Patients of either gender aged from 18 to 80 years, with Schatzker classification type V or VI with tibial tuberosity avulsion fractures diagnosed by X-ray and Computed Tomography (CT) scan of the knee joint, closed or Gustilo I/II/IIIA/IIIB open fractures, and patients willing to come for follow-up, fractures less than two-week-old were included. Patients aged less than 18 or more than 80 years, fractures more than two-week-old, patients with pathological fractures, open growth plates, individuals suffering from serious head injuries with a Glasgow Coma Scale (GCS) <8, mental retardation, drug addiction, or other neurological problems that might impede rehabilitation, severe systemic diseases, such as uncontrolled diabetes mellitus, chemotherapy, aggressive malignancy, or renal failure, Gustilo grade IIIC fractures, patients with fractures in any ipsilateral or contralateral limbs, and those who were not willing to participate or come for follow-up, were excluded.

Sample size calculation: Out of the total 20 patients initially included in the study, two were lost to follow-up. Therefore, the final sample included eighteen patients with tibial plateau fractures (Schatzker type V or VI) associated with tibial tuberosity avulsion fractures. Tibial tuberosity plating with a thin profile distal fibular plate was performed, and all patients received bi-columnar plating.

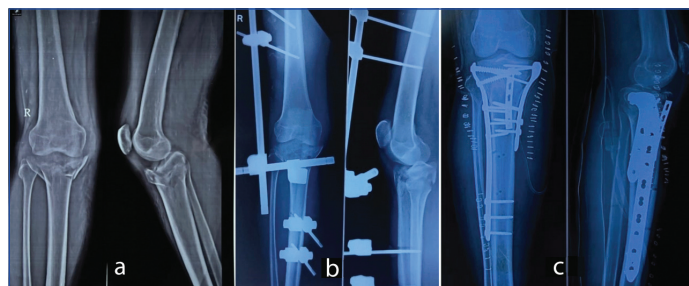
Study Procedure

A plaster slab or knee immobiliser was used to splint the injured limb. Following their medical condition, the state of the skin around the fracture, and the degree of swelling, the patients underwent surgery as early as possible. When there was significant soft-tissue swelling, the patient was placed in a knee-spanning external fixator or distal tibial skeletal traction was applied until the soft-tissue condition improved. The wrinkling of the skin around the proximal tibia, healing of fracture blisters, and decreased oedema were the clinical signs of soft-tissue recovery. Every procedure was performed under the guidance of an image intensifier on a C-arm.

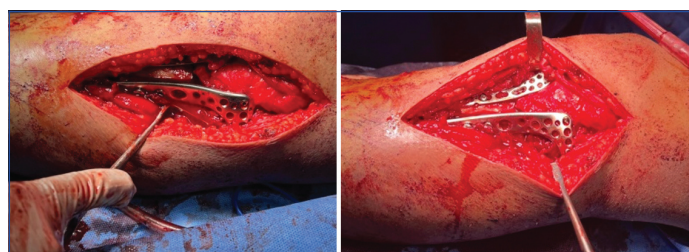
All the patients underwent surgery under either general or regional spinal anaesthesia. Cefuroxime 1.5 mg intravenously was initiated half an hour before the administration of anaesthesia. During the surgery, an inflated tourniquet was used in each patient. Patients were positioned supine on a radiolucent table with a sandbag placed under the ipsilateral gluteal region. If a posteromedial approach was planned, the sandbag was placed on the contralateral hip side.

The medial column is often fixed first. Initially, the lateral column was reconstructed when the medial condyle was severely comminuted. In cases where the fragment was posterior, an open posteromedial approach was employed. By adequately retracting the gastrocnemius and pes anserinus, the posteromedial fragment was made visible. The anatomical reduction was achieved by adequately visualising the fragment. Fracture reduction was confirmed under fluoroscopic guidance. Then, a 3.5-mm medial proximal tibial Locking Compression Plate (LCP) or T buttress plate was used to hold the reduced fracture in place. For the anterolateral technique, a lazy 'S' incision was made parallel to the tibial shin, just lateral to the tibial tuberosity. Anatomical lateral locking plates, 'L' shaped buttressing plates, or lateral tibial raft plates were fixed to the lateral surface after achieving satisfactory reduction under the C-arm. Tibial tuberosity avulsions were fixed with thin-profile

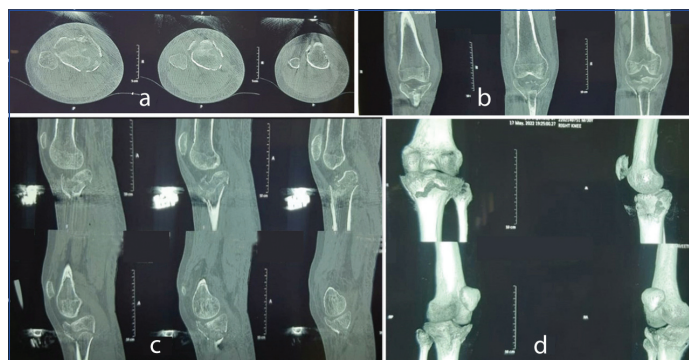
distal fibular plates in buttressing mode for all patients [Table/Fig-1a-c]. A contralateral thin-profile distal fibular plate was utilised to provide a buttressing effect. This plate was preferred as it could sit flush over the tibial tuberosity, offering a broad buttressing effect on the tuberosity fragment. Other precontoured plates did not sit flush over the tuberosity fragment. The intraoperative images showing plating has been depicted in [Table/Fig-2]. CT knee images with Schatzker type V fracture and tibial tuberosity avulsion fracture has been depicted in [Table/Fig-3].



[Table/Fig-1]: X-rays of right knee joint (a) Preoperative (b) Postoperative spanning external fixator and (c) Post operative after bi-columnar plating along with thin distal fibular plating.



[Table/Fig-2]: Intraoperative images following plating.



[Table/Fig-3]: CT knee images with Schatzker type V fracture and tibial tuberosity avulsion fracture (a) Axial section, (b,c) Coronal section and (d) 3D reconstruction image.

Patients were monitored postoperatively to track recovery and detect any issues. Radiographs were used to assess the effectiveness of articular reduction, metaphyseal-diaphyseal reduction, and alignment. In cases of remaining instability postsurgery, a hinged knee brace was recommended. Static quadriceps strengthening activities and non weight-bearing walking were initiated on the first postoperative day. Non weight-bearing mobilisation was performed using a walking frame or axillary crutches. Active assisted knee bending and quadriceps exercises began on the second postoperative day.

Fracture healing progress and knee joint Range of Motion (ROM) were monitored. The functional outcome of the patients was assessed over a one-year period using the Knee Society knee scoring system [Table/Fig-4] [15].

STATISTICAL ANALYSIS

Descriptive statistics were used to compute means, standard deviations, and ranges. The Statistical Package for Social Sciences (SPSS) version 11.0 was used to analyse the data. Student's t-tests and ANOVA were used to compare two means. Correlations were analysed using the Pearson's correlation coefficient. A p-value of 0.05 was considered statistically significant.



[Table/Fig-4]: Clinical images showing knee range of movements in a 30-year-old male patient at 12-month postsurgery.

RESULTS

The average age of the study population was 39.4±5.6 years. Road Traffic Accident (RTA) was the most frequent mode of injury in 14 (77%) individuals. Within the study group, no perioperative problems were recorded. The surgery took 114±10.4 minutes on average, and 146±40 mL was the average blood loss recorded throughout the procedure [Table/Fig-5].

Mode of injury		Average duration of surgery (Min)	Average blood loss in surgery (mL)	Average bone union time (weeks)	Average time to full weight bearing (weeks)
Road traffic accident	14 (77%)	114±10.4	146±40	12.7	15.8
Slip and fall	2 (11.1%)				
Fall from height	2 (11.1%)				

[Table/Fig-5]: Mode of injury, average duration of surgery and average blood loss in surgery.

After an average duration of 12.4 weeks (range: 11-15 weeks), radiographic bone union was seen in 16 individuals, with union occurring between 10 and 14 weeks [Table/Fig-5]. Every patient exhibited outstanding healing. The average time to begin full weight-bearing was 15.8 weeks (range: 12-24 weeks) [Table/Fig-5]. Two patients showed signs of union in further follow-ups after 14 weeks. There were no complaints of anterior knee pain. The Knee Society score at 12 months postoperatively was excellent at 93.6 (range 92 to 98). The affected knees exhibited an average Range of Motion (ROM) between 90.3 and 120.1 degrees. One patient developed a wound-related complication in the form of a superficial skin infection, which was treated with antibiotics and eventually subsided. One patient developed postoperative screw loosening for which screw exit was done. Another case had a 2° varus deformity and had a good functional score at the end of the follow-up.

Many radiographic abnormalities were observed, such as varus collapse, expansion and depression of the articular surfaces, preservation of fracture reduction, union in cortex or trabeculae across the fracture site, and evidence of subsequent osteoarthritis.

The union of bone was defined as “The union of at least three cortices in the Anteroposterior (AP) and lateral views, on follow-up radiographs”. There was no mortality reported during the study period. Knee society scoring at 12 months postoperatively was 88%, which falls in the excellent criteria, and 12% of patients were in the good category.

DISCUSSION

The present study explores a new surgical technique for treating complex tibial plateau fractures. Current methods prioritise stable fixation of the fracture but can limit knee mobility. The most common

cause of complex tibial plateau fractures is high-energy trauma. The comminution that follows makes it challenging to analyse fracture patterns. The fractures are categorised by the Schatzker and AO/OTA classifications based on how they appear on anteroposterior radiographs [3,5]. In present study, the use of additional thin-profile plates alongside traditional medial and lateral plates for the tibia was examined. A fibular plate, which is thin in profile and can be contoured to accommodate the tibial tuberosity, was also considered. Another advantage of using a thin fibular plate is that it reduces hardware prominence. The goal was to achieve both stable fixation and early knee movement, potentially leading to improved patient outcomes. The best site for the fibular plate, according to the study, is directly anterior to the tibial tuberosity. Through the anteromedial or anterolateral incisions made for bicondylar fracture fixation, soft-tissue dissection can be done medially until the patellar tendon is visualised, and fine dissection can be done distally to its insertion at the tibial tuberosity.

In present study, the average union time was 12.7 weeks. In other Zhang Y et al., studies, an average of 14.1 weeks was reported for the bi-columnar cohort [17]. Fracture union was observed to occur between 8 and 22 weeks, with an average of 14 weeks, according to Prasad GT et al., [18]. The treatment of tibial tuberosity avulsion fractures with additional thin-profile distal fibular plates and the stiff fixation of the proximal tibia utilising medial and lateral plates allowed for early knee mobilisation [18].

Knee society scoring was conducted, revealing 88% excellent and 12% good outcomes after a 1-year follow-up in 16 patients who underwent thin distal fibular plating for tibial tuberosity avulsion fractures. This outcome was comparable to the study conducted by Rohra N et al., where patients with Schatzker type V and type VI fractures received bi-columnar plating, resulting in almost 70% of patients with excellent and 23% with good knee scores. The bi-columnar tibial plates used on the medial and lateral aspects have been in use for a considerable period. Notably, the avulsion injuries anteriorly were not addressed [Table/Fig-6] [19].

Grade	Rohra N et al., [19] (%)	Present study
Excellent (80-100)	24 (70%)	16 (88%)
Good (70-79)	8 (23%)	2 (12%)
Fair (60-69)	1 (2.9%)	0
Poor (<60)	1 (2.9%)	0
Total	34	18

[Table/Fig-6]: Comparison of Knee Society Scores at 1-year follow-up with the study conducted by Rohra N et al., [19].

Early knee mobilisation was facilitated by the use of medial and lateral plates for stiff fixation of the proximal tibia and additional thin-profile distal fibular plates for treating tibial tuberosity avulsion fractures. Weight-bearing is typically postponed until X-rays show signs of union (usually between 12 and 16 weeks). Acute arthritic changes, metaphyseo-diaphyseal alignment, and articular congruity were assessed using AP and lateral plane radiographs of the knee joint and leg.

Severe comminution can cause malalignment and wound dehiscence in high-intensity intra-articular tibial plateau fractures. A delay in healing may lead to implant failure, varus collapse, and arthritis in the knee joint [20,21]. Various techniques have been proposed for repairing fractures, including bi-columnar plating using Minimally Invasive Percutaneous Plate Osteosynthesis (MIPPO) procedures, external fixation, hybrid fixators, plating through a single midline incision, plating using Mercedes Benz incisions, and plating through two incisions. To regain good Range of Motion (ROM) and to avoid progressive osteoarthritis, secure internal fixation with restoring articular congruity and ligament restoration are crucial. Open reduction of the fracture and fixation with plates should be done as soon as possible after the accident, ideally within four hours,

or preferably one week later when the oedema and related inflammatory reactions have subsided. Patients underwent surgery after an average waiting period of 3.5 days.

However, present study addresses proximal tibial avulsion fractures using the buttress technique. The avulsed fragments are usually difficult to manage and control. Thin profile distal fibular plates were used for addressing these types of fractures. These thin profile plates also had excellent results concerning skin healing due to their less prominence over the bony aspects of the anterior tibia.

The present study investigated the treatment of complex tibial plateau fractures with a focus on achieving good knee function. The study found that using a combination of medial and lateral plates for the tibia and additional plates for tibial tuberosity avulsion fractures allowed for early knee movement after surgery.

Limitation(s)

The insufficient follow-up period might not capture long-term effects or outcomes. The sample size was small, which was not calculated. This might influence the results. A longer duration study with a wider patient population and an appropriate control group will be better to validate the outcome of present study.

CONCLUSION(S)

A unique thin-profile distal fibular plating technique for tibial tuberosities may be an effective treatment for difficult proximal tibia Schatzker type V and VI fractures with tibial tuberosity avulsion fractures. Columnar plates combined with open reduction and internal fixation through two incisions with thin distal fibular plates produce excellent/good functional results. This innovative and safe technique helps provide sound fixation and stability for faster and early mobilisation without any anterior knee pain and promotes quicker fracture healing. Appropriate timing of the operation, excellent extraperiosteal dissection, and avoiding dissection of comminuted bone fragments can all help minimise postoperative problems.

REFERENCES

- [1] Reátiga Aguilar J, Ríos X, González Edery E, De La Rosa A, Arzuza Ortega L. Epidemiological characterization of tibial plateau fractures. *J Orthop Surgery and Research*. 2022;17:106.
- [2] Kugelman D, Qatu A, Haglin J, Leucht P, Konda S, Ego K. Complications and unplanned outcomes following operative treatment of tibial plateau fractures. *Injury*. 2017;48(10):2221-29.
- [3] Watson JJ, Wiss AD. Rockwood and Green's fractures in adults: Fractures of the proximal tibia and fibula. Bucholz RW and Heckman JD Ed. 5th ed. Philadelphia: Lippincott Williams and Wilkins; 2001;2:1799-1839.
- [4] Muller M, Allgower M, Schneider R, Willenegger H, et al. Patella and tibia. In: Allgower M, ed. *Manual of Internal Fixation*. New York: Springer-Verlag; 1979: 553-94.
- [5] Schatzker J. Tibial plateau fractures. In: Browner BD, Jupiter JB, Levine AM, et al, eds. *Skeletal Trauma. Fractures, Dislocations, Ligamentous Injuries*. Vol. 2. Philadelphia: WB Saunders; 1992: 1759.
- [6] Rommens PM, El Attal R, Hansen M, Kuhn S. Intramedulläre Nagelung von proximalen Tibiafrakturen [Intramedullary nailing of proximal tibia fractures]. *Oper Orthop Traumatol*. 2011;23(5):411-22.
- [7] Raj M, Gill S, Rajput A, Singh KS, Verma KS. Outcome analysis of dual plating in management of unstable bicondylar tibial plateau fracture- A prospective study. *Malays Orthop J*. 2021;15(3):29-35.
- [8] Saini R, Sharma A, Sidhu SS, Rathore KS. Bridge plating versus hybrid external fixation in the management of proximal tibia metaphyseal fractures. *Cureus*. 2023;15(3):e36331.
- [9] Gálvez-Sirvent E, Ibarzábal-Gil A, Rodríguez-Merchán EC. Complications of the surgical treatment of fractures of the tibial plateau: Prevalence, causes, and management. *EFORT Open Rev*. 2022;7(8):554-68.
- [10] Tschern H, Lobenhoffer P. Tibial plateau fractures. Management and expected results. *Clin Orthop Relat Res*. 1993;292:87-100.
- [11] Luo CF, Sun H, Zhang B, Zeng BF. Three-column fixation for complex tibial plateau fractures. *J Orthop Trauma*. 2010;24(11):683-92. Doi: 10.1097/BOT.0b013e3181d436f3. PMID: 20881634.
- [12] Youssef AHE, Nagi A, Senna WGA, Othman SA, Elgamal H. Does single locked plating provide a standard treatment Modality for bicondylar tibial plateau fractures? A prospective study. *Rheumatol Orthop Med*. 2017;2(3):01-07.
- [13] Patil SN, Srinivas P, Bhandary D. Prospective study of management of Schatzker's type V and VI tibial plateau fractures by different types of plate osteosynthesis. *Int J Res Orthop*. 2017;3(5):1070-77.
- [14] Lee MH, Hsu CJ, Lin KC, Renn JH. Comparison of outcome of unilateral locking plate and dual plating in the treatment of bicondylar tibial plateau fractures. *J Orthop Surg Res*. 2014;9:62.
- [15] Scuderi GR, Bourne RB, Noble PC, Benjamin JB, Lonner JH, Scott WN. The new Knee Society Knee Scoring System. *Clin Orthop Relat Res*. 2012;470(1):03-19. Available from: <https://doi.org/10.1007/s11999-011-2135-0>.
- [16] Nimityongskul P, Montague WL, Anderson LD. Avulsion fracture of the tibial tuberosity in late adolescence. *J Trauma*. 1988;28(4):505-09.
- [17] Zhang Y, Fan D, Ma B, Sun S. Treatment of complicated tibial plateau fractures with dual plating via a 2-incision technique. *Orthopedics*. 2012;35(3):e359-64.
- [18] Prasad GT, Kumar TS, Kumar RK, Murthy GK, Sundaram N. Functional outcome of Schatzker type V and VI tibial plateau fractures treated with dual plates. *Indian J Orthop*. 2013;47(2):188-94.
- [19] Rohra N, Suri HS, Gangrade K. Functional and radiological outcome of Schatzker type V and VI tibial plateau fracture treatment with dual plates with minimum 3 years follow-up: A prospective study. *J Clin Diag Res*. 2016;10(5):RC05-RC10. Available from: <https://doi.org/10.7860/JCDR/2016/18732.7855>.
- [20] Oh CW, Oh JK, Kyung HS, Jeon IH, Park BC, Min WK, et al. Double plating of unstable proximal tibial fractures using minimally invasive percutaneous osteosynthesis technique. *Acta Orthop*. 2006;77(3):524-30.
- [21] Hassankhani EG, Kashani FO, Hassankhani GG. Treatment of complex proximal tibial fractures (Types v & vi of Schautzker classification) by double plate fixation with single anterior incision. *Open Journal of Ortho*. 2013;3(4):208-12.

PARTICULARS OF CONTRIBUTORS:

1. Professor and Head, Department of Orthopaedics, Saveetha Institute of Medical and Technical Sciences (SIMATS), Chennai, Tamil Nadu, India.
2. Assistant Professor, Department of Orthopaedics, Saveetha Institute of Medical and Technical Sciences (SIMATS), Chennai, Tamil Nadu, India.
3. Associate Professor, Department of Orthopaedics, Saveetha Institute of Medical and Technical Sciences (SIMATS), Chennai, Tamil Nadu, India.
4. Senior Resident, Department of Orthopaedics, Saveetha Institute of Medical and Technical Sciences (SIMATS), Chennai, Tamil Nadu, India.
5. Assistant Professor, Department of Orthopaedics, Saveetha Institute of Medical and Technical Sciences (SIMATS), Chennai, Tamil Nadu, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:

Dr. Naveen Sathiyaseelan,
Associate Professor, Department of Orthopaedics, Saveetha Institute of Medical and Technical Sciences (SIMATS), Thandalam, Chennai-602117, Tamil Nadu, India.
E-mail: spnaveen17@gmail.com

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

PLAGIARISM CHECKING METHODS: [Jan H et al.]

- Plagiarism X-checker: Dec 12, 2023
- Manual Googling: Feb 26, 2024
- iThenticate Software: Jul 17, 2024 (13%)

ETYMOLOGY: Author Origin

EMENDATIONS: 8

Date of Submission: Dec 12, 2023
Date of Peer Review: Feb 24, 2024
Date of Acceptance: Jul 18, 2024
Date of Publishing: Sep 01, 2024