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Original Article

Orthopaedics Section

Early Bony Fixation and Soft Tissue Coverage in Type IIIB Open Proximal Tibia Fractures: A Cross-sectional Study

PANKAJ KUMAR VERMA[1], SURENDRA KUMAR[2], AVINASH SINGH[3], MOHAMMAD VASEEM[4], HS SHRISHMA[5]

ABSTRACT

Introduction: The tibia, the second largest bone in the human body, is largely enveloped by subcutaneous fat and skin, rendering it vulnerable to fractures and soft tissue injuries. This unique anatomical configuration contributes to a heightened susceptibility to open fractures. Notably, an aggressive treatment protocol involving radical debridement, internal fixation, and immediate or early soft tissue coverage with muscle flaps has demonstrated improved rates of bony union and reduced incidences of infection.

Aim: To assess the clinical outcomes of early bony fixation and soft tissue coverage in Type IIIB open proximal tibia fractures.

Materials and Methods: This cross-sectional observational study was conducted at the Department of Orthopaedics, BRD Medical College, in Gorakhpur, Uttar Pradesh, India. Total of 30 cases were enrolled between August 2021 and November 2022. The parameters assessed in the study encompassed patient demographics, including age and gender distribution, the aetiology of fractures, soft tissue coverage outcomes, time to bone union, knee joint movement postsurgery, and the incidence of complications such as superficial infections and chronic osteomyelitis. The analysis was conducted using Statistical Package for Social Sciences (SPSS) version 26.0, primarily employing descriptive statistics to present the results, with percentages and frequencies serving as the primary modes of representation.

Results: All cases of Gustilo-Anderson Type IIIB high-grade open tibial fractures were included in this study, with the majority of patients being males 26 (87%) aged between 20 to 40 years. Road traffic accidents accounted for 25 (83.3%), while falls from height were responsible in 5 (16.7%) cases. Assessment of soft tissue coverage revealed 73.33% with good healing, 20% with fair healing, and 6.67% with poor healing. The time to bone union varied, with 10% of cases showing non union. Postsurgery, most cases demonstrated knee joint movement of over 120° (86.67%) and a few cases with movement ranging between 90-120° (13.33%). The incidence of complications was relatively low, with 3 (10%) cases presenting superficial infections and 2 (6.7%) suffering from chronic osteomyelitis.

Conclusion: Early bony fixation and soft tissue coverage utilising the medial gastrocnemius flap, along with Split-Thickness Skin Grafting (STSG), demonstrate efficacy in treating high-grade open proximal tibia fractures (Gustilo-Anderson Type IIIB). This approach facilitates expedited bony union and contributes to a reduction in postoperative complications.

Keywords: Flaps, Fractures, Injuries, Skin grafts

INTRODUCTION

Tibia fractures are common due to their specific anatomy and vulnerable soft tissue covering, leading to an increased risk of soft tissue injuries and a high incidence of open tibial fractures. Historically, open tibia fractures were managed through repeated debridement, external fixation, and delayed soft tissue coverage, resulting in persistent complications [1,2]. Surgical interventions for open tibial fractures, without adequate attention to soft tissues, can result in deep infections, malunion, non union, implant failure, and may even jeopardize the limb, necessitating amputation. Improved outcomes in the surgical treatment of tibial fractures have been facilitated by the implementation of sterile surgical techniques and antibiotic prophylaxis. The outcome is significantly influenced by the injury mechanism, extent of comminution, and soft tissue condition [3,4]. The Gustilo open fracture classification system stands as the most widely employed system for categorising open fractures [5]. Originating from the work of Ramón Gustilo and Anderson, it underwent subsequent refinement by Gustilo, Mendoza, and Williams [6]. This classification relies on evaluating the energy imparted, the extent of soft tissue damage, and the level of contamination to determine the severity of the fracture. Advancing from Grade I to IIIC signifies escalating levels of energy in the injury, heightened damage to soft tissues and bones, and an increased likelihood of complications. It is crucial to note that a Gustilo score of grade 3C indicates not only bone and connective tissue damage but also vascular injury [6].

Successful treatment of open tibial fractures hinges upon achieving three critical goals: preventing infection, achieving bony union, and restoring preoperative function [7]. The primary focus in managing open tibia fractures revolved around early soft tissue coverage, prompt union, and infection prevention. Godina M proposed the use of early free microvascular flaps to cover large contaminated wounds. An aggressive protocol, comprising radical debridement, internal fixation, and immediate or early soft tissue coverage with muscle flaps, has been reported to expedite union and lower infection rates [8]. Early soft tissue coverage of Type III open tibial fractures significantly reduces the rates of infection, non union, and late amputation. Various options for closing soft tissue defects in open fractures include Split Skin Graft (SSG), fasciocutaneous flap, rotational muscle flap (with SSG), and free muscle flap (with SSG) [9]. Non microvascular flaps are less technically demanding and can be used to cover the soft tissue defects in open tibial fractures. Typically, tissue defects in the proximal third of the tibia are managed with a gastrocnemius rotational flap in conjunction with STSG [10,11]. An orthopaedic surgeon, equipped with comprehensive knowledge of the local vascular anatomy, is well-suited to harvest an appropriate local or regional flap to cover exposed bone or metal in open tibia fractures. Given their extensive experience with extremity surgery, orthopaedic surgeons are ideally positioned to reconstruct soft tissue defects in these injuries as promptly as possible.

Considering these factors, the current study aim to evaluate the management of open proximal tibia fractures through early bony fixation and soft tissue coverage, utilising the medial gastrocnemius flap with STSG, while assessing both bone healing and functional outcomes.

MATERIALS AND METHODS

A cross-sectional observational study was conducted at the Department of Orthopaedics, BRD Medical College, Gorakhpur, Uttar Pradesh, India, which is a tertiary care teaching hospital. Over a period spanning from August 2021 to November 2022, 30 cases were enrolled in the study after obtaining informed consent from each participant. The study received ethical approval from the Institute's Ethical Committee (IEC) (No. 51/CRC/2021 dated 27/08/21).

Inclusion criteria: Patients diagnosed with Gustilo-Anderson Grade IIIB fractures were included in the study.

Exclusion criteria: Patients who did not consent to surgical intervention, those with multiple injuries including head, abdominal, chest, and other limb injuries, as well as those falling under Gustilo-Anderson Grades I, II, IIIA, and IIIC [6] were excluded from the study.

Initial resuscitation involved administering intravenous fluids and immobilising the injured limb with a Thomas/Bohler's brown splint, preceded by an assessment of distal neurovascular and soft tissue status in the emergency department. Concurrently, a thorough evaluation ruling out injuries to the head, thorax, and abdomen was conducted, followed by the classification of the wound using the Gustilo-Anderson classification [6] and the Ganga Hospital Open Injury Scoring System [12].

Post-resuscitation, wound irrigation with copious normal saline and debridement within the first six hours, along with the application of betadine-soaked dressings, was performed. Wound swabs were collected for culture and sensitivity testing, with broad-spectrum intravenous antibiotics initiated. Subsequent redebridement within 72 hours was performed as deemed necessary, ensuring complete removal of necrotic tissue. The application of the medial gastrocnemius muscle flap with STSG was the chosen surgical intervention for proximal third tibia fractures, following patient stabilisation.

Postoperatively, limb elevation was maintained to prevent oedema and graft failure. The initial wound inspection and dressing change occurred on the fourth postoperative day. Patients with definitive internal fixation were permitted partial weight-bearing from 4 to 6 weeks, followed by full weight-bearing as soon as radiological evidence of sound union appeared. Patients treated with an external fixator underwent removal of the fixator once the wound exhibited a healthy flap, followed by a subsequent secondary procedure involving definitive internal fixation using plates and intramedullary nails.

The first follow-up evaluation typically occurred between 4 to 6 weeks postoperatively, with subsequent regular follow-ups scheduled every 4 to 6 weeks until complete fracture union was achieved. Thus, the parameters included patient demographics, aetiology of fractures, soft tissue coverage outcomes, time to bone union, knee joint movement postsurgery, and the incidence of complications such as superficial infections and chronic osteomyelitis.

STATISTICAL ANALYSIS

The collected data were analysed using SPSS version 26.0. Descriptive statistics were employed to present the results, including percentages and frequencies to illustrate the outcomes.

RESULTS

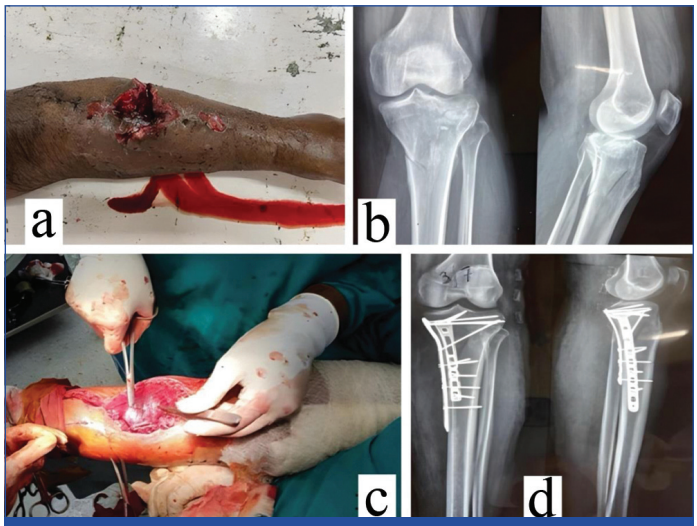
The study comprised 30 cases of high-grade open tibial fractures (Gustilo-Anderson Type IIIB), with 87% being male and 13% female patients, predominantly within the age group of 20-40 years. The leading causes of these fractures were road traffic accidents, accounting for 25 (83.3%) cases, followed by falls from height, contributing to 5 (16.7%) cases.

The evaluation of soft tissue coverage outcomes is shown in [Table/Fig-1].

Outcome	n (%)
Good	22 (73.33)
Fair	6 (20)
Poor	2 (6.67)
Total	30 (100)

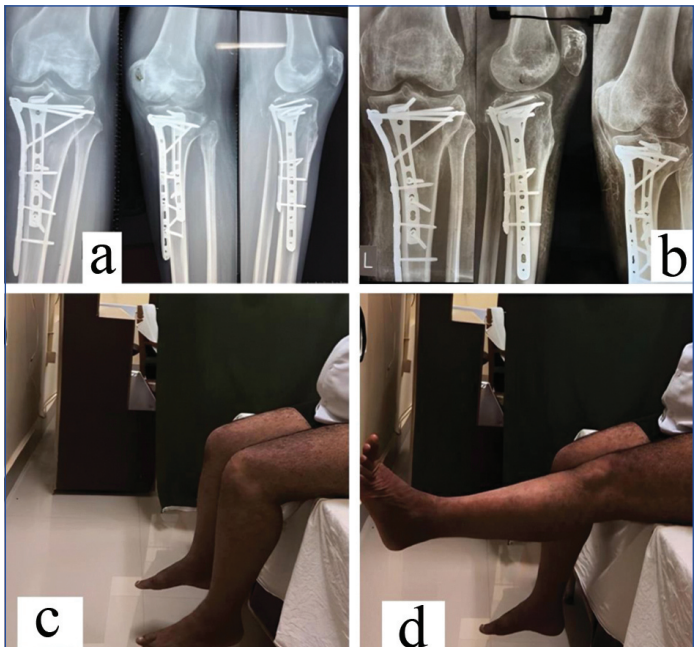
[Table/Fig-1]: Soft-tissue coverage outcomes.

During the study, the time taken for bone union varied, with 5 (16.7%) cases demonstrating union around 30 and 34 weeks each, 7 (23.3%) at approximately 28 weeks, 4 (13.3%) at around 26 weeks, 3 (10%) at 32 and 36 weeks each, while 2 (6.7%) and 1 (3.3%) displayed union at 24 and 40 weeks, respectively [Table/Fig-2]. Additionally, 3 (10%) of cases experienced non union during the study period.



[Table/Fig-2]: a) Clinical picture after the injury; b) Preoperative X-ray image displaying a fracture of the proximal tibia with intra-articular extension; c) Clinical picture illustrating the use of the medial gastrocnemius flap; d) Immediate postoperative X-ray image.

Postsurgery, knee joint movement was assessed, revealing that 26 (86.7%) cases exhibited a range of movement exceeding 120°, whereas 4 (13.3%) cases displayed knee joint movement ranging between 90-120°. The majority of cases demonstrated favourable movement postsurgery during the study [Table/Fig-3].



[Table/Fig-3]: a) Follow-up X-ray image after three months, demonstrating union in progress; b) X-ray image after one year of follow-up, showing complete union; c) Follow-up image with flexion at the knee; d) Follow-up image with full extension at the knee joint.

Furthermore, the study noted that the majority of cases 25 (83.3%) did not experience any complications, while 3 (10%) cases presented with superficial infections, and 2 (6.7%) patients suffered from chronic osteomyelitis.

DISCUSSION

The findings of this study underscore the efficacy of early bony fixation and soft tissue coverage, utilising the medial gastrocnemius flap with STSG, in the management of high-grade open proximal tibia fractures (Gustilo-Anderson Type IIIB). These interventions demonstrated favourable outcomes, including expedited bone union, successful soft tissue healing, and improved knee joint mobility. Moreover, the low incidence of postoperative complications, coupled with the notable reduction in non union cases, highlights the effectiveness of the implemented approach in achieving the desired clinical outcomes.

Open tibial fractures are commonly associated with complex fracture patterns, limb-threatening soft tissue damage, and the potential for severe arterial haemorrhage. Karikalan T conducted a study involving 20 patients with Type IIIB open tibial fractures treated through skeletal stabilisation and soft tissue coverage, either via a fasciocutaneous flap or a myocutaneous flap. The study concluded that early soft tissue coverage is instrumental in promoting favourable bone healing and enhancing limb function [13]. Similarly, present study findings align with this conclusion, emphasising that early soft tissue coverage, specifically through the utilisation of the myocutaneous flap, facilitates prompt bony union and early restoration of limb function.

In present sudy the functional outcomes of soft tissue coverage, primarily utilising the medial gastrocnemius flap, revealed that 22 (73.3%) cases exhibited a good functional outcome, 6 (20%) demonstrated a fair functional outcome, and 2 (6.7%) indicated a poor outcome. Most cases exhibited positive functional outcomes during follow-up. Comparative results from other studies are presented in [Table/Fig-4] [14,15].

Related studies	Publi-cation year	Study place	Sample	% Good functional outcome	% Fair functional outcome	% Poor functional outcome
Gamulin A et al., [14]	2022	Switzerland	725	80	12	8
Court-Brown CM et al., [15]	2012	Edinburgh, UK	2386	62	16	22
Present study	2023	Uttar Pradesh, India	30	73.33	20	6.67

[Table/Fig-4]: Comparative results from present study and other studies [14,15].

Sandhu KS et al., conducted a study on high-grade open tibial fractures, revealing a bone union rate of 50% of cases between 24-30 weeks [16], as indicated by other studies presented in [Table/Fig-5] [17-19]. In contrast, present study demonstrated a more favourable outcome, with 60% of cases achieving bone union within the same timeframe of 24-30 weeks. This discrepancy underscores the potential variations in outcomes across different studies and reinforces the significance of individualised approaches in managing high-grade open tibial fractures.

Related studies	Publica-tion year	Study place	Sample size	Maximum % of cases bony union in 28 weeks	Minimum % of cases bony union in 40 weeks	% of cases non union
Gill SP et al., [17]	2016	Uttar Pradesh, India	84	60	20	10
Metsemakers WJ et al., [18]	2015	Belgium	480	70	25	5
Gorczyca JT et al., [19]	2011	USA	-	45	30	25
Present study	2023	Uttar Pradesh, India	30	23.33	3.33	10

[Table/Fig-5]: Comparative bone union present study results with other studies [17-19].

Milner SA et al., conducted a study, reporting that 69% of cases had knee joint movement of more than 120°, with 31% showing movement between 90-120°. Another study by Weiss RJ et al., demonstrated that 80% of cases had knee joint movement of more than 120°, while 20% fell between 90-120° [20,21]. In comparison, present study revealed favourable outcomes, with 26 (86.7%) cases exhibiting knee joint movement exceeding 120° and 4 (13.3%) showing movement between 90-120°. This suggests that adherence to the established protocol and a one-year follow-up period contributed to notably positive results in terms of both bony union and functional outcomes.

Penn-Barwell JG et al., conducted a study where 22% of cases exhibited superficial infections, and 8% presented with deep infections. Similarly, Campion EM and Mackersie RC reported that 10% of cases showed superficial infections, and 12% presented with deep infections, specifically chronic osteomyelitis [22,23]. In contrast, present study revealed a notably lower incidence of complications, with approximately 3 (10%) cases presenting with superficial infections and 2 (6.7%) cases with chronic osteomyelitis. This suggests that the implemented approach in present study may contribute to a reduced risk of postoperative complications compared to some existing studies.

The success of this study and the achievement of satisfactory long-term outcomes are contingent upon diligent follow-up and comprehensive patient care. Notably, this study distinctive attributes, including its substantial sample size, rigorous authentication processes, and innovative approaches, contribute to its novelty within the field. Comparative studies within the existing literature are relatively scarce.

The available literature reviews have highlighted a significant gap concerning data on high-grade open proximal tibial fractures, specifically Gustilo-Anderson Type IIIB. This study plays a crucial role in addressing this gap, providing valuable insights into the management and outcomes of such fractures. The data generated not only contributes to the existing body of knowledge but also holds potential for guiding future research endeavours, particularly for young researchers. The findings of this study have the potential to benefit surgeons in refining their approaches and interventions, ultimately serving the broader community and advancing healthcare practices for the betterment of society.

Limitation(s)

The limitations observed during this study primarily include a comparatively smaller sample size, attributed to the unavailability of a larger number of cases, and the relatively short duration of the study, consequently leading to a limited follow-up period. A longer follow-up duration is essential for a more comprehensive assessment of the long-term outcomes associated with the use of the gastrocnemius flap for high-grade open tibial fractures. Additionally, while the descriptive analysis employed in this study provided valuable insights, future research endeavours employing inferential statistics and specific statistical tests would enhance the depth of understanding and contribute to a more rigorous evaluation of the data's significance.

CONCLUSION(S)

The study affirms that the approach of early bony fixation and soft tissue coverage, specifically utilising the medial gastrocnemius flap along with STSG, emerges as an efficacious strategy for the treatment of high-grade open tibial fractures (Gustilo-Anderson Type IIIB). The accessibility and ease of mobilisation of the gastrocnemius muscle, situated in close proximity to the proximal tibia, make it a practical choice for soft tissue coverage. The demonstrated success includes

expedited bony union within a shorter timeframe, accompanied by a favourable reduction in postoperative complications.

REFERENCES

[1] Norris BL, Kellam JF. Soft-tissue injuries associated with high-energy extremity trauma: Principles of management. J Am Acad Orthop Surg. 1997;5(1):37-46. Doi: 10.5435/00124635-199701000-00005. PMID: 10797206.

[2] Small JO, Mollan RA. Management of soft tissues in open tibial fractures. Br J Plast Surg. 1992;45(8):571-77.

[3] Lua J, Tan VH, Sivasubramanian H, Kwek EBK. Complications of open tibial fracture management: Risk factors and treatment. Malays Orthop J. 2017;11(1):18-22. Doi: 10.5704/MOJ.1703.006. PMID: 28435569; PMCID: PMC5393109.

[4] Nicolaides M, Pafitanis G, Vris A. Open tibial fractures: An overview. J Clin Orthop Trauma. 2021;20:101483. Doi: 10.1016/j.jcot.2021.101483. PMID: 34262849; PMCID: PMC8254044.

[5] Gustilo RB, Anderson JT. Prevention of infection in the treatment of one thousand and twenty-five open fractures of long bones: Retrospective and prospective analyses. J Bone Joint Surg Am. 1976;58(4):453-58.

[6] Gustilo RB, Mendoza RM, Williams DN. Problems in the management of Type-III (severe) open fractures: A new classification of Type-III open fractures. J Trauma. 1984;24(8):742-46. Doi: 10.1097/00005373-198408000-00009.

[7] Cross WW, Swiontkowski MF. Treatment principles in the management of open fractures. Indian J Orthop. 2008;42(4):377-86. Doi: 10.4103/0019-5413.43373. PMID: 19753224; PMCID: PMC2740354.

[8] Godina M. Early microsurgical reconstruction of complex trauma of the extremities. Plast Reconstr Surg. 1986;78(3):285-92. Doi: 10.1097/00006534-198609000-00001. PMID: 3737751.

[9] Elniel AR, Giannoudis PV. Open fractures of the lower extremity: Current management and clinical outcomes. EFORT Open Rev. 2018;3(5):316-25. Doi: 10.1302/2058-5241.3.170072. PMID: 29951271; PMCID: PMC5994617.

[10] Kamath JB, Shetty MS, Joshua TV, Kumar A, Harshvardhan, Naik DM. Soft-tissue coverage in open fractures of tibia. Indian J Orthop. 2012;46(4):462-69. Doi: 10.4103/0019-5413.97265. PMID: 22912523; PMCID: PMC3421938.

[11] Meena M, Chavan V, Ghilley SK, Jangir NK. Soft-tissue coverage techniques for management of open fractures of tibia (Type-IIIB). Int J Res Orthop. 2020;6(4):773-76.

[12] Rajasekaran S, Sabapathy SR, Dheenadhayalan J, Sundararajan SR, Venkatramani H, Devendra A, et al. Ganga hospital open injury score in management of open injuries. Eur J Trauma Emerg Surg. 2015;41(1):03-15. Doi: 10.1007/s00068-014-0465-9. Epub 2014 Nov 6. PMID: 26038161.

[13] Karikalan T. Flaps in management of open tibia fractures. Int J Res Orthop. 2019;5(3):504-08.

[14] Gamulin A, Wuarin L, Zingg M, Belinga P, Cunningham G, Gonzalez AI. Association between open tibia fractures and acute compartment syndrome: A retrospective cohort study. Orthop Traumatol Surg Res. 2022;108(5):103188. Doi: 10.1016/j.otsr.2021.103188. Epub 2021 Dec 17. PMID: 34929394.

[15] Court-Brown CM, Bugler KE, Clement ND, Duckworth AD, McQueen MM. The epidemiology of open fractures in adults. A 15-year review. Injury. 2012;43(6):891-97. Doi: 10.1016/j.injury.2011.12.007. Epub 2011 Dec 27. PMID: 22204774.

[16] Sandhu KS, Pal D, Kumar A, Singh J, Sharma AK, Singh K. Functional outcome of monorail fixator as a primary and definitive mode of fixation in open fractures of tibia-an interventional study. J Clin Diagn Res. 2022;16(4):RC01-RC05.

[17] Gill SP, Raj M, Kumar S, Singh P, Kumar D, Singh J, et al. Early conversion of external fixation to interlocked nailing in open fractures of both bone leg assisted with Vacuum Closure (VAC)- final outcome. J Clin Diagn Res. 2016;10(2):RC10-14. Doi: 10.7860/JCDR/2016/17612.7265. Epub 2016 Feb 1. PMID: 27042541; PMCID: PMC4800607.

[18] Metsemakers WJ, Handojo K, Reynders P, Sermon A, Vanderschot P, Nijs S. Individual risk factors for deep infection and compromised fracture healing after intramedullary nailing of tibial shaft fractures: A single centre experience of 480 patients. Injury. 2015;46(4):740-45. Doi: 10.1016/j.injury.2014.12.018. Epub 2014 Dec 27. PMID: 25583638.

[19] Gorczyca JT, Roberts CS, Pugh KJ, Ring D. Review of treatment and diagnosis of acute compartment syndrome of the calf: Current evidence and best practices. Instr Course Lect. 2011;60:35-42. PMID: 21553760.

[20] Milner SA, Davis TRC, Muir KR, Greenwood DC, Doherty M. Long-term outcome after tibial shaft fracture: Is malunion important? J Bone Joint Surg Am. 2002;84(6):971-80. Doi: 10.2106/00004623-200206000-00011. PMID: 12063331.

[21] Weiss RJ, Montgomery SM, Ehlin A, Al Dabbagh Z, Stark A, Jansson KA. Decreasing incidence of tibial shaft fractures between 1998 and 2004: Information based on 10,627 Swedish inpatients. Acta Orthop. 2008;79(4):526-33. Doi: 10.1080/17453670710015535. PMID: 18766487.

[22] Penn-Barwell JG, Bennett PM, Fries CA, Kendrew JM, Midwinter MJ, Rickard RF. Severe open tibial fractures in combat trauma: Management and preliminary outcomes. Bone Joint J. 2013;95-B(1):101-05. Doi: 10.1302/0301-620X.95B1.30580. PMID: 23307681.

[23] Campion EM, Mackersie RC. Recent developments in the assessment of the multiply injured trauma patient. Curr Opin Crit Care. 2014;20(6):620-25. Doi: 10.1097/MCC.0000000000000151. PMID: 25290911.

PARTICULARS OF CONTRIBUTORS:

1. Postgraduate Resident, Department of Orthopaedics, BRD Medical College, Gorakhpur, Uttar Pradesh, India.
2. Associate Professor, Department of Orthopaedics, BRD Medical College, Gorakhpur, Uttar Pradesh, India.
3. Senior Resident, Department of Orthopaedics, BRD Medical College, Gorakhpur, Uttar Pradesh, India.
4. Postgraduate Resident, Department of Orthopaedics, BRD Medical College, Gorakhpur, Uttar Pradesh, India.
5. Senior Resident, Department of Anaesthesia, BRD Medical College, Gorakhpur, Uttar Pradesh, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Surendra Kumar,
Associate Professor, Department of Orthopaedics, BRD Medical College,
Gorakhpur-273013, Uttar Pradesh, India.
E-mail: doctorsurendra82@gmail.com

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