International Journal of Research in Orthopaedics
Raghavendra R et al. Int J Res Orthop. 2026 Sep;12(5):1399-1404
https://www.ijoro.org

Original Research Article

DOI: https://dx.doi.org/10.18203/issn.2455-4510.IntJResOrthop20262910

Role of antibiotic-coated intramedullary nails and antibiotic beads in the management of infected nonunion of long bones

Raghavendra R.*, Prakash A. Sasnur

Department of Orthopaedics, Al-Ameen Medical College Hospital, Vijayapura, Karnataka, India

Received: 19 June 2026
Revised: 05 August 2026
Accepted: 11 August 2026

***Correspondence:**
Dr. Raghavendra R.,
E-mail: ragugowdack7866@gmail.com

ABSTRACT

Background: Infected non-union of long bones remains a challenging condition in orthopaedic practice because of the coexistence of infection, bone instability and impaired fracture healing. Antibiotic-coated intramedullary nails and antibiotic beads provide simultaneous local antibiotic delivery and mechanical stabilization, thereby improving infection control and fracture union. To evaluate the clinical and functional outcomes of antibiotic-coated intramedullary nails and antibiotic beads in the management of infected non-union of long bones.
Methods: This prospective study included 20 patients with infected non-union of long bones treated with antibiotic-coated intramedullary nails and antibiotic beads between January 2024 and January 2026. Clinical, microbiological, radiological and functional outcomes were assessed. Infection control, fracture union, time to union, complications and functional outcomes according to the Paley scoring system were evaluated during follow-up.
Results: The majority of patients belonged to the 21–30 years age group (35%). The tibia was the most commonly affected bone (60%), followed by the femur (40%). Staphylococcus aureus was the most common organism isolated (50%). Infection control was achieved in 70% of patients, while radiological union was observed in 80% of cases. The mean time to union was 26.25±5.57 weeks. According to the Paley functional scoring system, excellent and good outcomes were achieved in 45% and 25% of patients respectively. Postoperative complications were absent in 70% of patients, while reinfection occurred in 20%, implant failure in 5% and persistent sinus in 5% of cases.
Conclusions: Antibiotic-coated intramedullary nails and antibiotic beads are effective treatment modalities for infected non-union of long bones, providing satisfactory infection control, fracture union and functional outcomes. The combined advantages of local antibiotic delivery and mechanical stabilization make this technique a reliable option in the management of infected non-union.

Keywords: Antibiotic-coated intramedullary nail, Antibiotic beads, Fracture union, Infection control, Infected non-union, Long bones, Osteomyelitis

INTRODUCTION

Fractures of long bones such as the tibia and femur are common following high-velocity trauma including road traffic accidents, falls and industrial injuries and contribute significantly to morbidity and disability worldwide.[1] Under normal conditions, fracture healing progresses through inflammation, repair and remodelling. However, non-union, defined as failure of fracture healing within the expected period without further intervention, remains a serious complication.[2] When non-union is associated with infection, management becomes considerably more challenging. Infected non-union results in persistent inflammation, impaired osteogenesis, chronic osteomyelitis, deformity, soft tissue compromise and functional disability, often requiring repeated surgical procedures and prolonged treatment.[3] The incidence of non-union varies according to fracture type and severity,

with higher rates observed in open fractures and tibial shaft injuries. Infection following fracture fixation and infected non-union continue to impose substantial clinical and economic burden because of prolonged hospitalization, repeated surgeries, extended antibiotic therapy and delayed rehabilitation.[4-6]

In India, infected non-union of long bones remains a major orthopaedic challenge due to the high burden of trauma and delayed presentation to tertiary care centres. Recent advances in management include the use of antibiotic-coated intramedullary nails and antibiotic beads, which provide both local antibiotic delivery and fracture stability. These techniques achieve high local antibiotic concentration with minimal systemic toxicity and simultaneously promote infection control and bone healing. Previous studies have reported encouraging rates of infection eradication and fracture union using antibiotic-impregnated polymethylmethacrylate (PMMA)-coated nails and beads.[7-9] Considering the clinical challenges associated with infected non-union, the present study was undertaken to evaluate the functional outcome of antibiotic intramedullary nailing and antibiotic beads in the management of infected non-union of long bones.

The aim of the study was to evaluate the functional outcome of antibiotic intramedullary nailing and antibiotic beads in the management of infected non-union of long bones. The objectives were to assess the biological advantages of antibiotic cement-coated nails and beads and to evaluate the clinical and radiological outcomes in patients with infected non-union of the femur and tibia treated using antibiotic-impregnated PMMA-coated nails and beads.

METHODS

This prospective study was conducted in the Department of Orthopaedics at Al-Ameen Medical College and Hospital from January 2024 to January 2026. The study included 20 patients with infected non-union of long bones who fulfilled the inclusion criteria and provided informed written consent.

Patients were evaluated through detailed history taking, clinical examination, radiological assessment using anteroposterior and lateral radiographs and laboratory investigations including random blood sugar, blood urea, serum creatinine, complete blood count, erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), culture and sensitivity, blood grouping, bleeding time/clotting time, HIV, HCV and HBsAg testing.

Patients aged between 18 and 60 years with infected non-union of long bones, shortening less than 2 cm, open fractures and mild to moderate infections were included in the study. Patients allergic to vancomycin or gentamicin, those with shortening greater than 2 cm, deformity or age below 18 years or above 60 years were excluded.

The treatment protocol included the use of antibiotic-coated intramedullary nails or antibiotic beads PMMA mixed with vancomycin (2–3 g) and gentamicin (500 mg). Postoperatively, patients received culture-sensitive antibiotics, analgesics, regular wound dressing, physiotherapy and functional rehabilitation.

Patients were followed up at 6 weeks, 3 months, 6 months and 1 year after surgery. During each follow-up visit, clinical evaluation for pain, swelling, recurrence of purulent discharge and range of motion was performed. Haematological parameters including total leukocyte count, ESR and CRP were assessed and radiological evaluation was carried out to assess bone healing and evidence of union.

Outcome assessment was performed clinically and radiologically. Clinical evaluation included assessment of active range of motion, recurrence of pain and persistence of sinus or discharge. Radiological assessment included evaluation for non-union, absence of bridging callus and presence of sclerotic fragments.

Data were entered into Microsoft Excel and analysed using SPSS version 28. Continuous variables were expressed as mean±standard deviation or median with interquartile range, while categorical variables were presented as frequencies and percentages. Associations between variables were analysed using Chi-square test for categorical data and independent Student's t-test for continuous variables. A p-value of less than 0.05 was considered statistically significant.

RESULTS

A total of 20 patients with infected non-union of long bones were included in the present study. The majority of patients belonged to the 21–30 years age group (35%), followed by 31–40 years (25%). Female patients constituted 55% of the study population, while males accounted for 45%.

The tibia was the most commonly affected bone, observed in 60% of cases, whereas femoral involvement was seen in 40% of patients. Left-sided involvement predominated (70%) compared to right-sided involvement (30%). Mild infection was observed in 65% of patients, while 35% had moderate infection. Most patients presented within three months of onset of infection, with the highest proportion having a duration of infection of three months (30%).

With regard to treatment modality, antibiotic-coated intramedullary nails were used in 70% of patients, whereas antibiotic beads were utilized in 30% of cases. Microbiological culture demonstrated *Staphylococcus aureus* as the most common isolate (50%), followed by *E. coli* and *Klebsiella* (20% each), while Pseudomonas was isolated in 10% of patients. All isolates were sensitive to vancomycin and gentamicin and these antibiotics were administered in all patients.

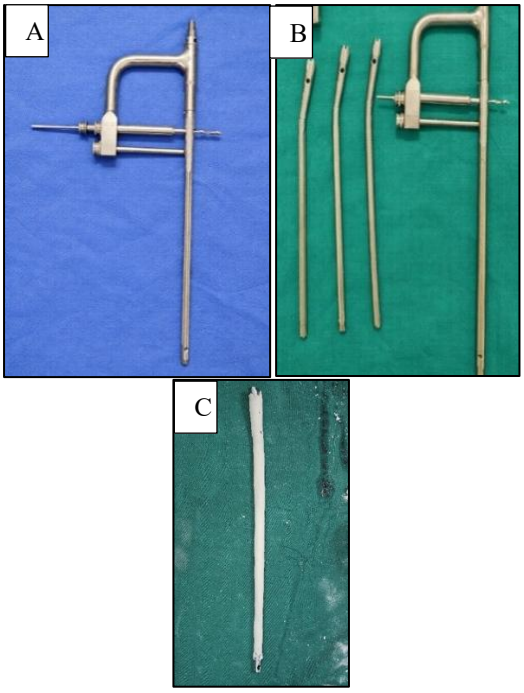

Figure 1 (A-C): Antibiotic nail of different sizes with jig, Antibiotic cement coated nail.

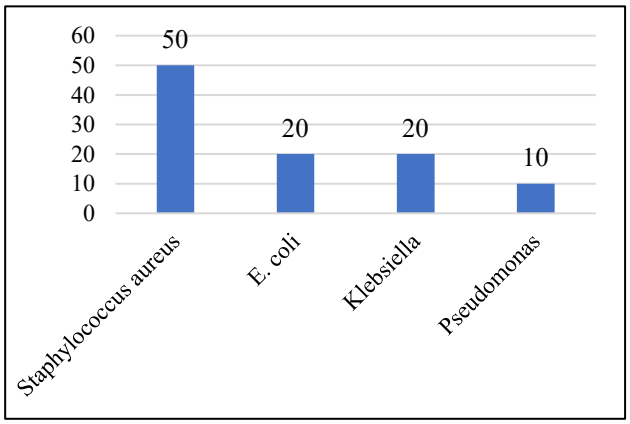

Figure 2: Culture isolates among the study participants.

The mean white blood cell count was 12,266.20±2,072.22 cells/mm³. The mean preoperative ESR and CRP values were 65.00±14.90 mm/hr and 34.05±14.43 mg/l respectively, which reduced postoperatively to 43.20± 19.42 mm/hr and 24.30±15.58 mg/l, indicating improvement in inflammatory status following treatment.

The mean duration of surgery was 117.80±17.05 minutes and the mean intraoperative blood loss was 427.15±113.09 ml. Intraoperative complications were observed in 20% of patients, whereas 80% had no operative complications. Postoperatively, infection control was successfully achieved in 70% of patients. Radiological union was observed in 80% of cases. Among patients achieving union, the majority demonstrated fracture healing within 26–29 weeks, with a mean time to union of 26.25±5.57 weeks. Functional assessment using the Paley scoring system showed excellent outcomes in 45% of patients and good outcomes in 25%, while fair and poor outcomes were observed in 10% and 20% respectively. Postoperative complications were absent in 70% of patients. Reinfection occurred in 20% of cases, while implant failure and persistent sinus were each observed in 5% of patients.

Figure 3 (A-H): Case of 28 years old male patient with 5 months old infected non-union of left distal tibia; Clinical image with discharging wound; Pre op X-ray; Intra-op insertion of antibiotic coated nail; 3 months post op X-ray; (E) 6 months post op X-ray; 1 Year post op X-ray; post op wound and range of motion.

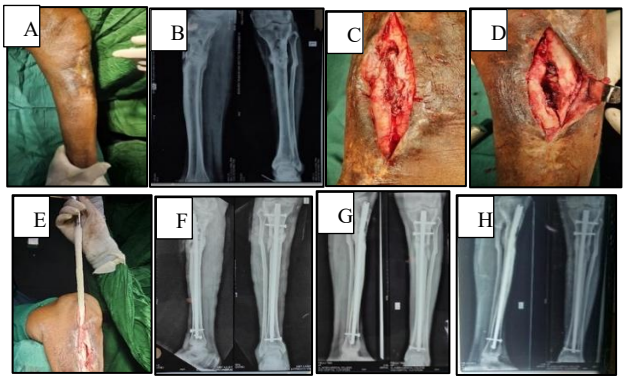

Figure 4 (A-H): Case of 58 Years old male patient with 11 months old infected nonunion of left proximal 1/3rd tibia, Clinical image with discharging wound; Pre op X-ray; debridement of the medullary canal and infected site, post debridement; Intra-op insertion of antibiotic coated nail; Immediate post op Xray; 3 months post op X-ray; 6 months post op X-ray.

Figure 5: Post op X-ray of antibiotic beading.

Table 6: Antibiotic cement coated Intramedullary nail.

Table 1: Hematological and inflammatory parameters of study participants.

Parameters	Mean	Standard deviation
WBC count (cells/mm³)	12266.20	2072.22
ESR (Preoperative)	65.00	14.90
CRP (Preoperative)	34.05	14.43
ESR (Postoperative)	43.20	19.42
CRP (Postoperative)	24.30	15.58

Table 2: Treatment outcomes among study participants.

Variables	Category	Frequency (N)	(%)
Infection control	Achieved	14	70.0
	Not achieved	6	30.0
Radiological union	Yes	16	80.0
	No	4	20.0
Time to union (weeks) (n=16)	18–21	3	18.8
	22–25	4	25.0
	26–29	5	31.3
	30–33	1	6.3
	34–36	3	18.8

DISCUSSION

The management of infected non-union of long bones remains a major challenge in orthopaedic surgery because it requires simultaneous eradication of infection and achievement of stable fracture union. Chronic infection adversely affects bone biology, vascularity and soft tissue integrity, thereby impairing fracture healing and functional recovery. Antibiotic-coated intramedullary nails and antibiotic beads have emerged as effective treatment modalities because they provide both local antibiotic delivery and mechanical stabilization. In the present study, infected non-union was more commonly observed among young and middle-aged adults, with the highest proportion of patients belonging to the 21–30 years age group. Similar age distribution has been reported by Rajkumar et al, Nah et al, Palakandy et al, Pisal et al and Solanki et al, who demonstrated that infected non-union predominantly affects individuals in the economically productive age group due to increased exposure to trauma and high-energy injuries.[10-14] Unlike most previous studies that reported strong male predominance, the present study demonstrated a relatively balanced sex distribution with slight female predominance.

The tibia was the most commonly affected bone in the present study, followed by the femur. Similar findings were reported by Solanki et al and Solanki et al who also observed predominance of tibial involvement.[14,15] This may be attributed to the subcutaneous location of the tibia and its relatively poor soft tissue coverage, making it more susceptible to open fractures, infection and delayed healing. Antibiotic-coated intramedullary nails were used in the majority of patients in the present study. Similar treatment approaches have been described by Deshmukh et al, Pisal et al and Rashed et al who emphasized the effectiveness of antibiotic-coated implants in providing local antibiotic delivery along with fracture stabilization.[13,16,17] This combined approach helps achieve infection control while promoting bone healing. Microbiological analysis in the present study demonstrated *Staphylococcus aureus* as the most common organism isolated from infected non-union cases. Comparable findings were reported by Rajkumar et al, Palakandy et al, Pisal et al and Rashed et al all of whom identified

Staphylococcus aureus as the predominant pathogen associated with infected non-union and chronic osteomyelitis.[10,12,13,17] Vancomycin and gentamicin showed sensitivity in all cases in the present study, supporting their continued role in local antibiotic therapy.

Infection control was achieved in 70% of patients in the present study. Although slightly lower than some previously reported studies, the findings remain comparable with available literature. Rajkumar et al, Palakandy et al, Solanki et al, Rashed et al and Saravanan A et al, reported infection eradication rates ranging from 90% to 96%.[10,12,13,15,17,18] Variations in infection control rates may be related to differences in severity of infection, duration before treatment, soft tissue status and patient-related factors. Radiological union was achieved in 80% of patients in the present study, with a mean time to union of approximately 26 weeks. Similar union rates were reported by Bhatia et al, Solanki et al, Solanki et al and Saravanan et al who demonstrated satisfactory fracture healing following antibiotic-coated intramedullary nailing.[14,15,18,19] These findings support the effectiveness of this technique in achieving both infection control and fracture union. Functional outcomes assessed using the Paley scoring system showed that the majority of patients achieved excellent or good results. Similar observations were reported by Palakandy et al, Solanki et al and Saravanan et al who demonstrated satisfactory restoration of limb function following treatment with antibiotic-coated implants.[12,14,18]

Postoperative complications in the present study included reinfection, implant failure and persistent sinus formation. Similar complications have been documented in previous studies. Bhatia et al reported nail breakage, migration and recurrence of infection, while Palakandy et al and Solanki et al described complications including cement debonding, nail bending and persistent non-union.[12,14,19] Despite these complications, the majority of patients in the present study achieved satisfactory clinical and radiological outcomes.

CONCLUSION

The present study demonstrates that antibiotic-coated intramedullary nails and antibiotic beads are effective treatment modalities in the management of infected non-union of long bones. This approach provided satisfactory infection control, successful fracture union and favourable functional outcomes in the majority of patients. The combined advantage of local antibiotic delivery and mechanical stabilization contributed to improved healing and reduced persistence of infection. Although complications such as reinfection and implant failure were observed in a few cases, the overall outcomes support the use of antibiotic-coated implants as a reliable and effective strategy for managing infected non-union of long bones.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

REFERENCES

1. Solanki T, Maurya MK, Singh PK. Results of antibiotic-impregnated cement/polymer-coated intramedullary nails in the management of infected nonunion and open fractures of long bones. Cureus. 2023;15(8):43421.
2. Rodriguez-Buitrago AF, Mabrouk A, Jahangir A. Tibia Non-union. In: StatPearls. Treasure Island (FL): StatPearls Publishing. 2025.
3. Chaudhary MM. Infected nonunion of tibia. Indian J Orthop. 2017;51(3):256–68.
4. Flores MJ, Brown KE, O'Marr JM, Adejuyigbe B, Rodarte P, Gomez-Alvarado F, et al. The economic impact of infection and/or nonunion on long-bone shaft fractures: a systematic review. OTA Int. 2024;7(3):337.
5. Flores MJ, Brown KE, O'Marr JM, Adejuyigbe B, Rodarte P, Gomez-Alvarado F, Nwachuku K, Urva M, Shearer D. The economic impact of infection and/or nonunion on long-bone shaft fractures: a systematic review. OTA International. 2024;7(3):337.
6. Natoli RM, Marchand LS, Bzovsky S, Hagen JE, Gage MJ, Stennett CA, et al. Infection and Nonunion Rates in Open Fractures. J Bone Joint Surg Am. 2025;107(22):2541–53.
7. Sen A, Kulkarni C, Meena A. Descriptive study of outcome of antibiotic cement-impregnated intramedullary nail in treatment of infected non-union of weight bearing long bones. Int J Res Orthopaed. 2019;5(6):1102–6.
8. Chavan V, Bairwa VK, Jhanwar P, Bohra AK. Role of antibiotic-impregnated cement intramedullary nail in infected non-union of long bone diaphyseal fractures. J Orthopaed, Traumatol Rehabil. 2019;11(1):16.
9. Walter N, Rupp M, Krückel J, Alt V. Individual and commercially available antimicrobial coatings for intramedullary nails for the treatment of infected long bone non-unions - a systematic review. Injury. 2022;53(3):74–80.
10. Rajkumar N, Mothilal M, Deol SS, Jothi VA. An interventional study on antibiotic cement-coated nails and cement beads in the management of infected nonunion of long bones. J Orthoped Joint Surgery. 2021;3(2):76–9.
11. Nah KH, Park SJ, Han SK, Song HS, Choi NY. Treatment of Infected Nonunion of Long Bone Shaft: Comparison between Fixation by Antibiotic-cement Loaded Intramedullary Nailing and Fixation by Antibiotic-cement Loaded External Monofixator. J Musculoskelet Trauma. 2016;16(4):511–8.
12. Palakandy A, Kunjappan M, Francis J. Functional outcome of antibiotic impregnated nail in infected non-union of tibia and femur - a prospective observational study, Trichur, Kerala. J Evid Based Med Healthcare. 2021;8:2620–4.
13. Pisal T, Hira YS, Solunke SS, Sangam SPB, Patil AC, Gupta S. Role of antibiotic-impregnated bone

cement rod in control of bone infection and assessing its role in union in cases of infective nonunion of long bones. J Orthop Spine. 2017;1;6(1):9–12.
14. Solanki T, Maurya MK, Singh PK. Results of antibiotic-impregnated cement/polymer-coated intramedullary nails in the management of infected nonunion and open fractures of long bones. Cureus. 2023;15(8):43421.
15. Solanki C, Sharma S, Verma R, Sharma K, Konat A, Jain P, et al. Antibiotic impregnated intramedullary nailing in compound fractures of long bones. IJSR. 2023;1:9–12.
16. Deshmukh A, Nair A, Devarmani S, Barosani A. Treatment of infected Tibia non-union using a novel solid intramedullary nail custom-made for antibiotic-impregnated cement coating. Cureus. 2024;16(8):65918.
17. Rashed R, Nigm M, Elaziz M, Shaheen E, Kandeel M. Management of infected nonunions by using antibiotic-impregnated bone cement. Egyptian Orthopaed J. 2016;51:26.
18. Saravanan A, Ganesh RR, Ismail ND, Anandan H. Antibiotic cement impregnated nailing in management of infected non-union of femur and Tibia. Int J Sci Study. 2017;5(4):187-91.
19. Bhatia C, Tiwari A, Sharma S, Thalanki S, Rai A. Role of antibiotic cement coated nailing in infected non-union of Tibia. Malays Orthop J. 2017;11(1):6–11.

Cite this article as: Raghavendra R, Sasnur PA. Role of antibiotic-coated intramedullary nails and antibiotic beads in the management of infected nonunion of long bones. Int J Res Orthop 2026;12:1399-404.