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STUDY OF THE RESULTS OF ANTIBIOTIC CEMENT COATED NAILS IN THE MANAGEMENT OF OPEN FRACTURE OF LONG BONES

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ABSTRACT

Background: Open long bone fractures are frequently complicated by infection and non-union. While external fixation is commonly used for stabilization, it is associated with complications. Recent evidence suggests that antibiotic cement-coated nails (ACCN) provide local antibiotic delivery and stable fixation, to reduce infection and improve outcomes. This study evaluated the effectiveness of ACCN in the management of open long bone fractures.

Methods: This ambispective study included 20 patients with Gustilo-Anderson Type II, IIIA, and IIIB open long bone fractures. After thorough debridement, custom-made ACCN were implanted. Patients were monitored using clinical, radiological, and haematological assessments The surgical protocol involved conversion to definitive interlocking intramedullary nailing once haematological markers normalized (at 3 or 6 weeks). If infection persisted, the ACCN was exchanged. Outcomes of infection control and fracture union were assessed at 3 and 6 months.

Results: The cohort comprised 17 males (85%) and 3 females (15%) with a mean age of 40.00 ± 11.55 years. Complete infection control was achieved in 16 patients (80%) by 3 weeks and in 2 patients (10%) by 6 weeks. Two patients (10%) required revision ACCN exchange due to persistent infection beyond 6 weeks. No cases of systemic antibiotic toxicity were observed. The majority of patients demonstrated successful fracture union and satisfactory functional outcomes.

Conclusion: ACCN are a highly effective therapeutic option for managing open long bone fractures. It providing targeted local infection control and stable fixation, that minimizes pin-site complications, reduces hospitalization, and promotes early rehabilitation. ACCN represents a robust approach to managing complex orthopaedic trauma.

Keywords: Accn, Tibia Fracture, Infection, Gustilo-Anderson Type Ii, Iii, Haematology.

INTRODUCTION

Fractures of long bones normally heal without com plication; however, open fractures provide a consid erable therapeutic challenge because to the higher risk of infection and non-union.[1] strict adherence to recognized protocols is necessar y for the management of these injuries.

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These procedures include early, vigorous debridem ent, appropriate stabilization, and soft-tissue reconstruction, all of which are intended to p revent fracture-related infection (FRI).[2]

The incidence of open long bone fractures is approximately 111.5 per 100000 population annually.[3]The risk of secondary infection correlates directly with the severity of the initial injury as defined by the Gustilo-Anderson classification, rising from less than 2% in grade I fraction to nearly 50% in grade III injuries.[4] In many clinical settings grade III fractures are definitively stabilized with external fixators, a practice associated with high rates of postoperative FRI. [4]

FRI remains a significant burden to orthopedic trauma care, it possess major complication that

adversely affects patient outcomes, prolongs hospital stays, and increases overall treatment costs.[5] While standard treatment protocols have achieved success in many cases, the persistent incidence of complications necessitates the development of more effective local antibiotic delivery systems. Although antibiotic-cement coated plates (ACCP) have shown promise in treating established infections and chronic post-traumatic osteomyelitis, there is a critical need to explore alternative modalities for acute fracture management.[6]

The efficacy of ACCN in managing open long bone fractures relies on a multimodal approach, integrating thorough surgical debridement, adequate soft-tissue coverage, and targeted systemic antimicrobial administration. ACCN systems provide a significant therapeutic advantage by facilitating the removal of infected hardware and enabling the high-concentration, local delivery of antibiotics directly to the site of injury. This approach allows local antibiotic levels to far exceed the minimum inhibitory concentration required to eradicate biofilms while avoiding the systemic toxicity often associated with prolonged intravenous therapy.[7, 8] Furthermore, this method offers a versatile solution for patients who are not ideal candidates for external fixation, those who may demonstrate poor compliance with long-term systemic antibiotic regimens, or those who find external fixation clinically or psychosocially unacceptable.[7]

Despite these advantages, further clinical data is required to optimize application protocols and confirm therapeutic success across diverse patient cohorts. Consequently, the aim of this study is to evaluate the clinical and radiological outcomes of antibiotic-cement coated nails in the management of open fractures of long bones, specifically assessing their efficacy in preventing infection-related complications and achieving fracture union.

MATERIALS AND METHODS

This ambispective, cross-sectional study was conducted over a three-year period. The study included 20 patients diagnosed with open long bone fractures. Inclusion criteria Gustilo-Anderson Type II, IIIa, and IIIb. Exclusion criteria patients less than 18 years, Gustilo-Anderson Type IIIc injuries, and patients with a history of prior trauma or surgical intervention in the affected limb.

Demographic details age, gender, occupation, relevant medical history, mechanism of injury were recorded.

Surgical Technique:

Following thorough surgical debridement and lavage, custom-prepared antibiotic-cement coated nails (ACCN) were inserted. (Fig: 1) Postoperative management was guided by serial clinical, radiographic, and hematological (CBC, ESR, CRP) evaluations.

Three-week assessment: If hematological markers showed a decreasing trend and normalized, the antibiotic nail was removed, and a definitive interlocking intramedullary nail was inserted. If markers remained elevated, a repeat antibiotic nail exchange was performed.

Six-week assessment: Following the second procedure, if hematological markers normalized, the antibiotic nail was removed, and definitive interlocking intramedullary nailing was performed. If signs of persistent infection remained, a secondary revision of the antibiotic nail was undertaken.

Postoperative Care and Follow-up:

Patients were discharged on a 2- to 4-week course of oral antibiotics, depending on wound status. Physical therapy was initiated postoperatively to restore joint mobility, and patients were encouraged to weight-bear as tolerated using assistive devices. Follow-up examinations occurred at 3 weeks, 6 weeks, 3 months, and 6 months to assess clinical progress, radiological union, and hematological status. Complications, including non-union, implant failure, or persistent infection, were systematically documented.

Fig 1: Antibiotic-impregnated cement coated intramedullary nail (K-nail)

Statistical Analysis

Analysis performed using IBM SPSS version 26.0 (released 2019; IBM Corp,New York, united states). Continuous variable were reported as median range, means, standard deviations, while categorical variables were reported as frequency and percentages.

RESULTS

Table No.1: Gender Distribution of the Study Population

Gender	Number of Patients	Percentage (%)
Male	17	85.0
Female	03	15.0

Graph No.1: Gender Distribution of the Study Population

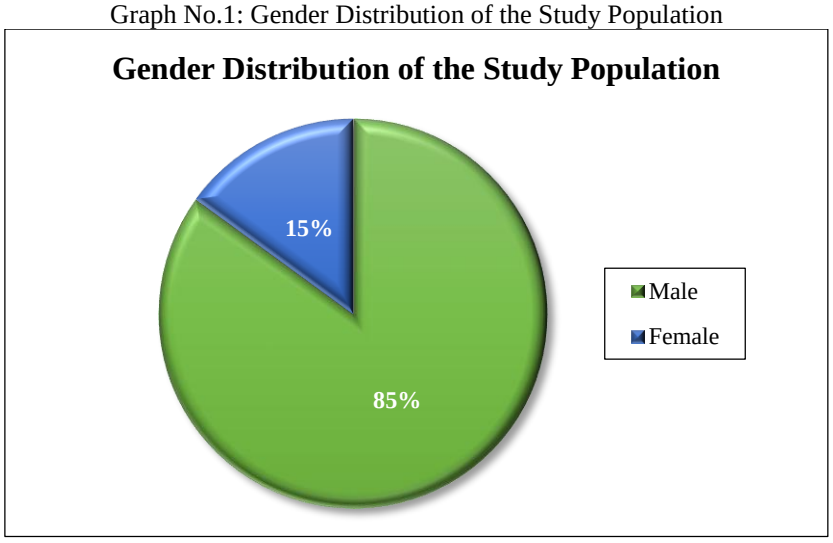

Table 1 showed the gender distribution of the study population. Among the 20 patients included in the study, 17 (85.0%) were male and 3 (15.0%) were female. The study population was predominantly male, with males accounting for the majority of patients who underwent management of open fractures of long bones using antibiotic cement-coated nails.

Table No.2: Age Distribution of the Study Population

Age Range In Years	Number of Patients	Percentage (%)
20-30	4	20.00

31-40	7	35.00
41-50	6	30.00
51-60	3	15.00
Total	20	100
Mean Age- 40.00 ± 11.55 Years | Range: 20 – 60 Years		

Graph No.2: Age Distribution of the Study Population

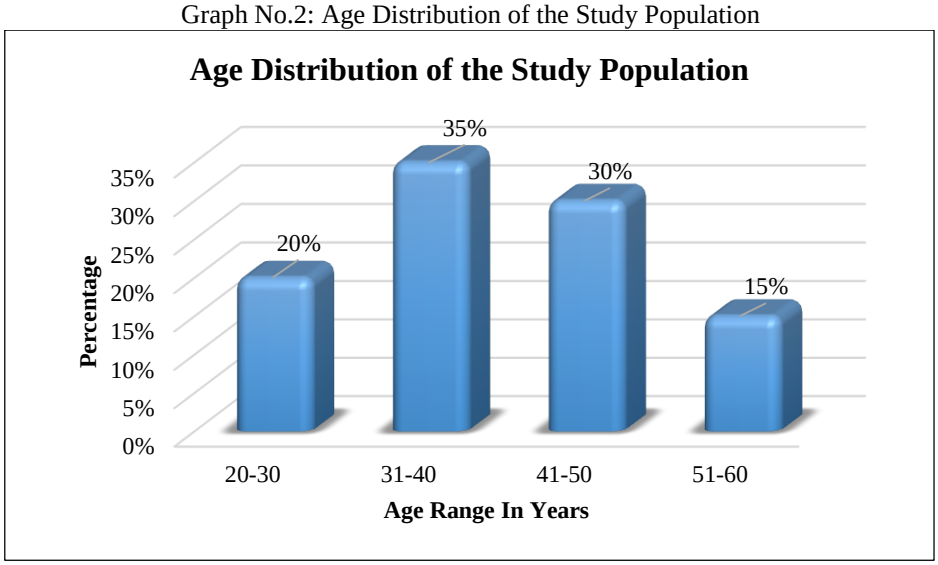

Table 2 showed the age distribution of the study population. The highest proportion of patients belonged to the 31–40 years age group, comprising 7 (35.0%) patients, followed by the 41–50 years age group with 6 (30.0%) patients. The 20–30 years age group included 4 (20.0%) patients, while the 51–60 years age group comprised 3 (15.0%) patients. The mean age of the study population was 40.00 ± 11.55 years, with an age range of 20–60 years.

Table No.3: Distribution of Patients According to Gustilo-Anderson Fracture Grade

Fracture Grade	Number of Patients	Percentage (%)
GA grade 2	06	30.0
GA grade 3A	11	55.0
GA grade 3B	03	15.0
Total	20	100
GA- Gustilo Anderson		

Graph No.3: Distribution of Patients According to Gustilo-Anderson Fracture Grade

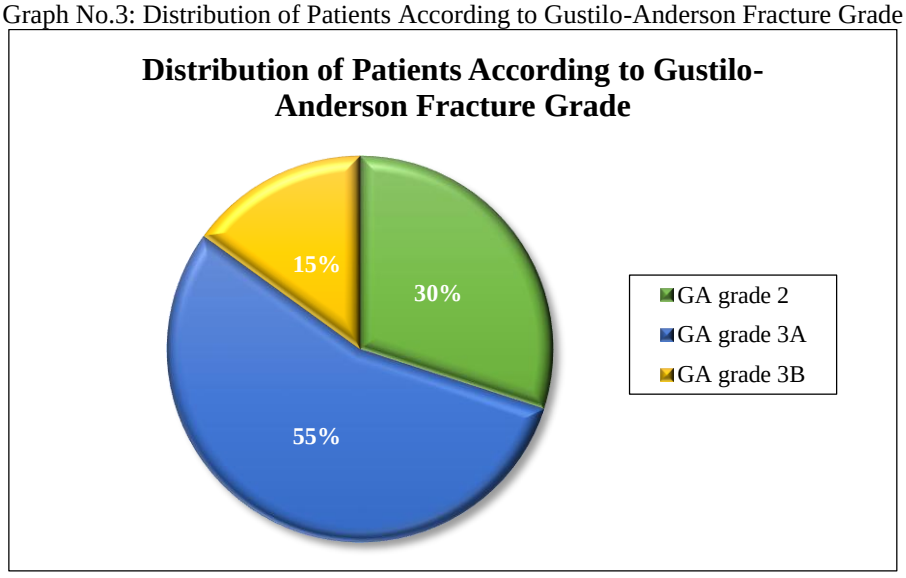

Table 3 showed the distribution of patients according to the Gustilo-Anderson (GA) fracture grade. The majority of patients, 11 (55.0%), had GA grade IIIA fractures, followed by 6 (30.0%) patients with GA grade II fractures. GA grade IIIB fractures were observed in 3 (15.0%) patients. Overall, GA grade IIIA was the most common fracture grade among the study population.

Table No.4: Distribution of Patients According to Long Bone Involved

Long Bones Involved	Number of Patients	Percentage (%)
Tibia	14	70.0
Femur	06	30.0
Total	20	100

Graph No.4: Distribution of Patients According to Long Bone Involved

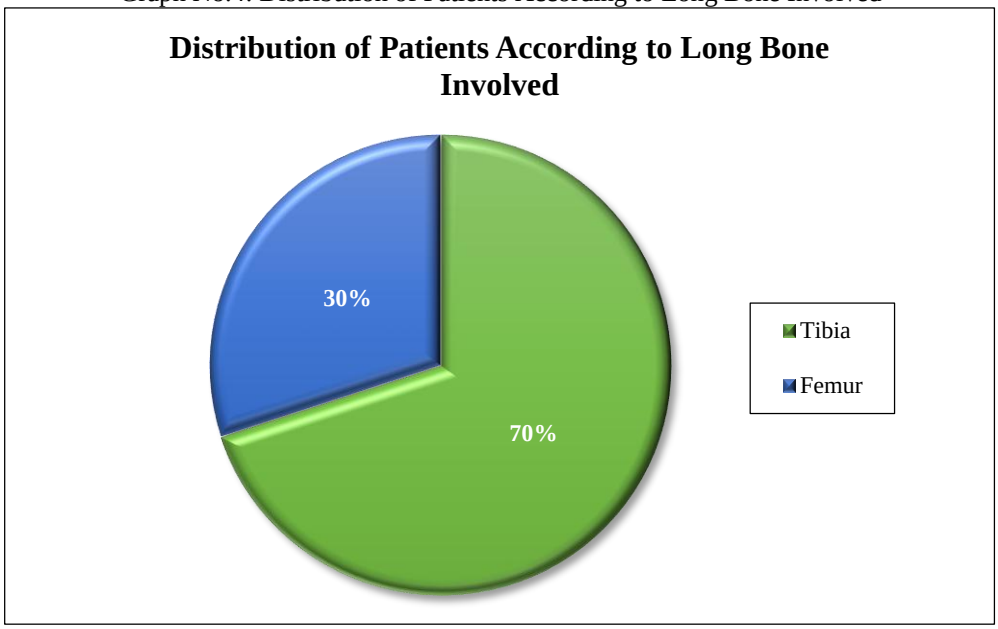

Table 4 showed the distribution of patients according to the long bone involved. Tibial fractures were observed in 14 (70.0%) patients, whereas femoral fractures were observed in 6 (30.0%) patients. Thus, the tibia was the most commonly involved long bone among the study population.

Table No.5: Changes in Haematological Parameters during the Follow-up Period

Haematological Parameters	Preoperative		Postoperative		3 Weeks		6 Weeks	
	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD	Range
CBC (total leukocyte count) (cells/µl)	13,594± 1,152	12,442-14,746	11,101 ± 1,272	9,829-12,373	9,709 ± 1,379	8,330-11,088	8,119± 1,410	6,706-9,529
ESR (erythrocyte sedimentation rate) (mm/hr)	57.3±6.3	51.0-63.6	45.8 ± 7.1	38.7-52.9	32.5 ± 8.2	24.3-40.7	21.0± 8.4	12.6-29.4
CRP (c reactive protein) (mg/L)	29.6± 5.9	23.7-35.5	20.6 ± 6.8	13.8-27.4	12.1 ± 7.4	4.7-19.5	7.6± **7.7**	0.5-15.3

Graph No.5: Changes in Haematological Parameters During the Follow-up Period

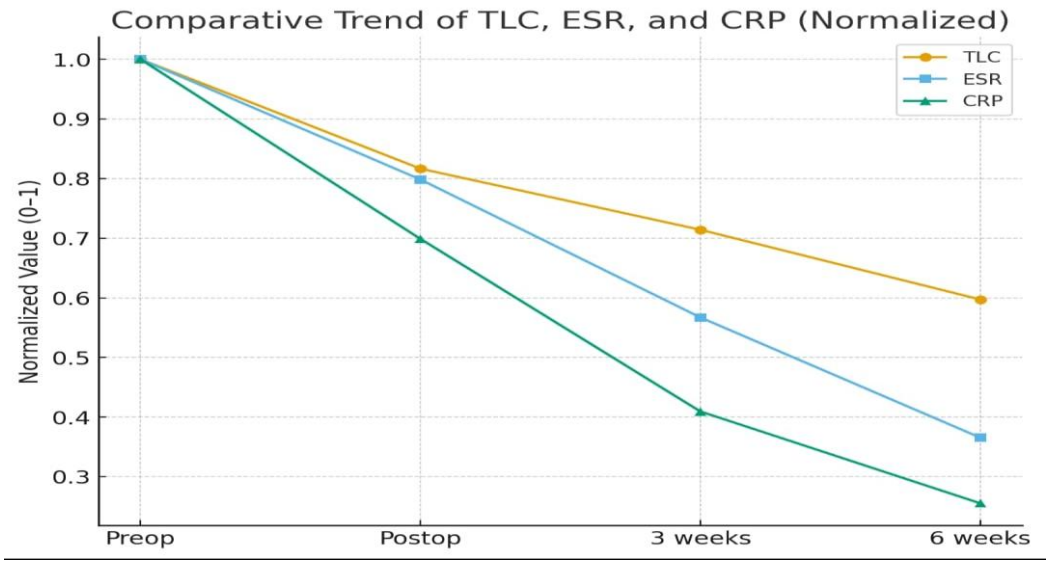

Table 5 showed the changes in haematological parameters from the preoperative period to 6 weeks postoperatively. The mean total leukocyte count decreased progressively from 13,594 ± 1,152 cells/µl preoperatively to 11,101 ± 1,272 cells/µl postoperatively, 9,709 ± 1,379 cells/µl at 3 weeks, and 8,119 ± 1,410 cells/µl at 6 weeks. Similarly, the mean erythrocyte sedimentation rate (ESR) declined from 57.3 ± 6.3 mm/hr preoperatively to 45.8 ± 7.1 mm/hr postoperatively, 32.5 ± 8.2 mm/hr at 3 weeks, and 21.0 ± 8.4 mm/hr at 6 weeks. The mean C-reactive protein (CRP) level also showed a progressive reduction from 29.6 ± 5.9 mg/L preoperatively to 20.6 ± 6.8 mg/L postoperatively, 12.1 ± 7.4 mg/L at 3 weeks, and 7.6 ± 7.7 mg/L at 6 weeks. Overall, all haematological parameters demonstrated a gradual decline throughout the follow-up period.

Table No.6: Clinical Outcomes of Antibiotic Cement-Coated Nails During Follow-up

Outcomes	**Mean ± SD**	**Range**
Mean Duration Of Study (In Weeks)	14.2+-5.8	From The Time Of Trauma- 6 Months
Infection Controlled	**Number of Patients**	**Percentage (%)**
Complete Infection Control Within 3 Weeks (Yes)	16	80.0
Persistent Infection After 3 Weeks	04	20.0
Out Of The Remaining Patient's (4(20.00%)) Complete Infection Control Within 6 Weeks (Yes)	02	10.0
Persistent Infection After 6 Weeks	02	10.0
If Yes (Complete Infection Control At 3 Weeks), Bone Involved (N=16)	**Number of Patients**	**Percentage (%)**
Tibia	12	75.0
Femur	04	25.0

Graph No.6: Clinical Outcomes of Antibiotic Cement-Coated Nails During Follow-up

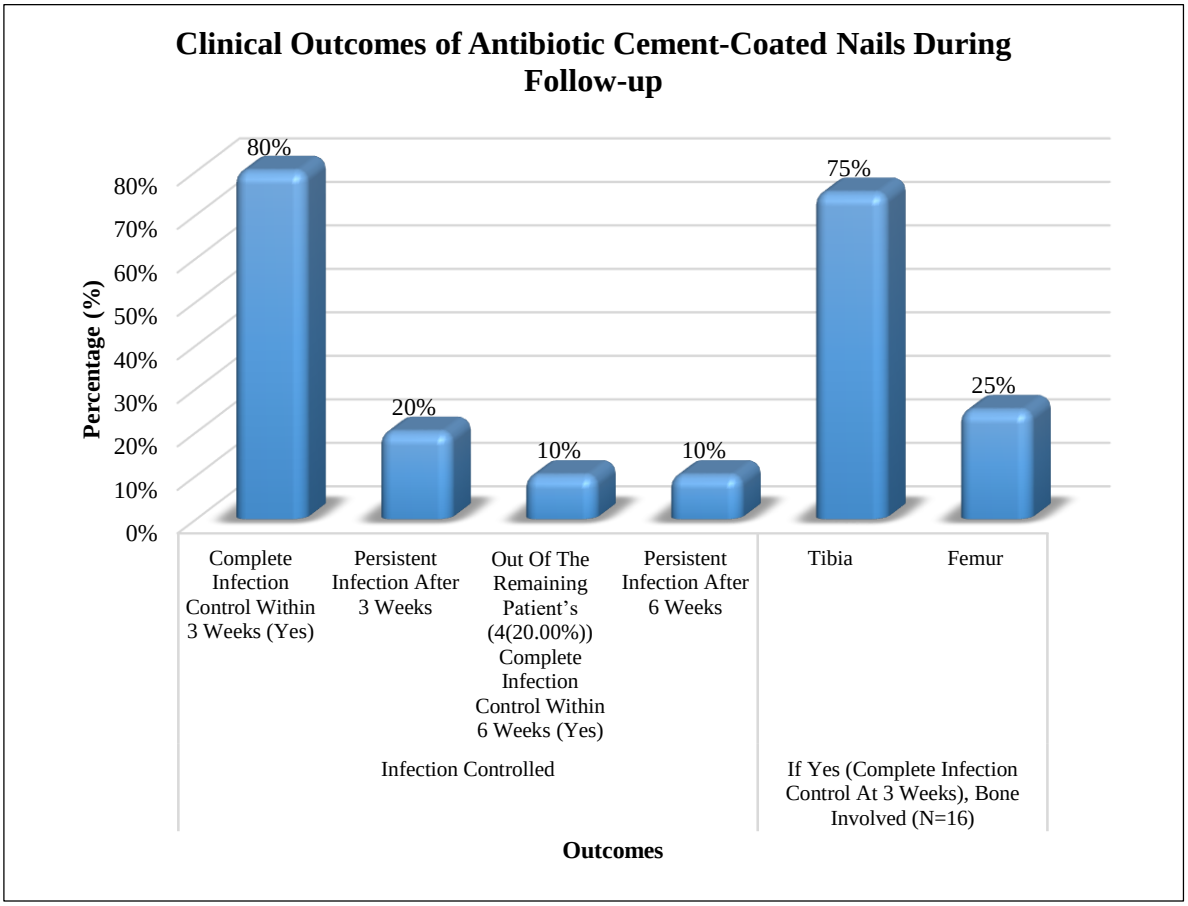

Table 6 showed the clinical outcomes of patients treated with antibiotic cement-coated nails during the follow-up period. The mean duration of the study was 14.2 ± 5.8 weeks, with follow-up extending from the time of trauma up to 6 months. Complete infection control within 3 weeks was achieved in 16 (80.0%) patients, while persistent infection was observed in 4 (20.0%) patients at the same time point. Among these four patients, infection was subsequently controlled within 6 weeks in 2 (10.0%) patients, whereas the remaining 2 (10.0%) patients continued to have persistent infection after 6 weeks.

Of the 16 patients who achieved complete infection control within 3 weeks, 12 (75.0%) had tibial fractures and 4 (25.0%) had femoral fractures. Overall, the majority of patients achieved successful infection control within the first 3 weeks following treatment.

Case:

27 year male presented with compound fracture distal 1/3rd shaft tibia right (Gustilo Anderson type 3B) complaining of pain,edema and lacerated wound over right leg with history of trauma related to RTA. Preoperative (Fig 3(a),4(a))

Fig 3 (a) : Preoperative clinical image

Fig4 (a): Preoperative X-ray suggestive of compound fracture distal 1/3rd of shaft tibia

First stage:
Following thorough debridement of wounds, custom-prepared antibiotic cement coated nails was implanted. Post-operative condition shown in Fig: 3(b), 4 (b)

Fig 3 (b) : Post-operative condition of wound

Fig: 4 (b) Post-operative X-ray antibiotic cement coated nail inserted.

Second stage- At 3 weeks antibiotic cement coated exchange nailing was done due to persistent infection (haematological parameters are not within the normal range).(Fig:5)

Fig 5: At 3 Weeks Antibiotic cement coated exchange nailing was done due to persistent infection

Third stage- At 6 weeks antibiotic cement coated nail removal followed by definitive fixation by intramedullary interlocking tibia nail was done (as haematological parameters are in decreasing trend and lie within the normal range) (Fig:6,7)

Fig: 6 at 6 weeks clinical image

Fig: 7 Antibiotic cement coated nail removal followed by definiative fixation by tibia interlock nail was done (haematological parameter lies within normal range and decreasing in trend

DISCUSSION

In the present study, we evaluated the outcomes of antibiotic-impregnated cement-coated intramedullary nails in the management of open long-bone fractures. Our findings demonstrated that this treatment modality achieved high rates of infection control and bone union, resulting in excellent radiological and functional outcomes.

The majority of patients were male (85%), with a mean age of 40.00 ± 11.55 years. Most fractures were Gustilo–Anderson grade IIIA (55.0%), followed by grade II (30.0%) and grade IIIB (15.0%), while the tibia was the most commonly involved bone. These findings are consistent with those reported by **Solanki et al.**,[1] who observed a mean age of 39.76 years, with most fractures classified as Gustilo–Anderson grade III (46.7%) and predominantly involving the tibia (73.3%). Similarly, **Vignesh et al.,**[3] reported a mean age of 40.3 years, with 72% male patients, road traffic accidents accounting for 65% of injuries, and the majority of fractures being Gustilo–Anderson grade II (75%), followed by grade IIIA (25%).

The present study showed after the treatment infection control in 80% of patients with majority patients controlled within the first 3 weeks. This finding was consistent with previous studies **Upadhyay et al.,** [8] directly compared antibiotic-coated and standard intramedullary nails in 100 patients with Gustilo–Anderson type I–IIIA open tibial shaft fractures and reported a significantly lower postoperative infection rate in the antibiotic-coated nail group (4% vs. 16%). They also observed a shorter time to fracture union and superior functional outcomes, without any systemic adverse effects related to local antibiotic delivery. These findings highlight the prophylactic benefit of antibiotic-coated nails in reducing infection and promoting fracture healing in open tibial fractures. **Garabano et al.**, [5] reported an even higher infection control of 96.7% in patients with established post traumatic osteomyelitis. **Meena et al.,** [10] similarly found that antibiotic-coated nails reduced infection incidence and improved union rates relative to uncoated nails. Their study concluded that local antibiotic elution form the cement coating reduce infection risk than mechanical fixation alone.

Present study investigation regarding haematological parameter showed a gradual decline form the preoperative period to 6 weeks after surgery. CRP, ESR value decreased most rapidly during first 3 weeks showing clinical improvement and infection control. These findings suggest that CRP is a reliable early indicator of treatment response, whereas ESR is more useful for monitoring longer-term recovery.

Overall finding suggest that antibiotic cement coated nailing is effective strategy offer both mechanical stability and effective local infection control in the management of open bone fractures.

The limitation of study is small sample size, single centre , absence of uncoated nail group . Futher study with large sample size, multi-

center, longer follow-up are needed to confirm these finding.

CONCLUSION

Antibiotic-impregnated cement-coated intramedullary nails are an effective and safe treatment option for the management of open long-bone fractures. This technique achieves high rates of infection control and fracture union while providing favorable radiological and functional outcomes. In addition to delivering high local antibiotic concentrations, it offers stable fracture fixation, facilitates early mobilization, reduces the need for staged procedures and external fixation, shortens hospital stay, and promotes faster rehabilitation. Therefore, antibiotic-impregnated cement-coated intramedullary nails represent a valuable treatment strategy for managing open long-bone fractures, particularly in patients at high risk of infection.

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