Outcome of antibiotics bone beads in long bone chronic osteomyelitis

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Abstract

Background: Chronic osteomyelitis of long bones is a challenging condition that requires prolonged antibiotic therapy. Local antibiotic delivery through bone beads has emerged as a potential strategy to improve infection control and promote bone healing.

Aim: This study aimed to evaluate the efficacy of antibiotic-impregnated bone beads in the management of chronic osteomyelitis of long bones in terms of infection resolution, bone healing, and functional outcomes.

Methods: A prospective study was conducted at Ayub Medical Hospital, Abbottabad, from January 2024 to March 2025. A total of 100 patients diagnosed with chronic osteomyelitis of long bones were included. Patients underwent surgical debridement followed by implantation of antibiotic-loaded bone beads. Clinical and radiological outcomes were assessed at regular intervals to determine infection eradication, bone regeneration, and overall functional recovery.

Results: The study found that 85% of patients achieved complete infection resolution within six months. Radiological evidence of bone healing was observed in 78% of cases. Functional recovery, assessed using the Musculoskeletal Tumor Society (MSTS) scoring system, showed significant improvement in 72% of patients. Only 10% of patients required additional surgical interventions due to persistent infection or inadequate bone healing. No major systemic complications related to antibiotic beads were reported.

Conclusion: Antibiotic bone beads proved to be an effective adjunct in the treatment of chronic osteomyelitis of long bones, demonstrating high infection eradication rates, improved bone healing, and satisfactory functional outcomes. This localized drug delivery method minimized systemic side effects and reduced the need for prolonged systemic antibiotic therapy.

Keywords

Chronic osteomyelitis, antibiotic bone beads, long bones, infection control, bone healing, local antibiotic therapy.

Introduction

Chronic osteomyelitis of long bones had remained a challenging condition in orthopedic surgery, characterized by persistent infection, bone destruction, and prolonged morbidity. It had often resulted from inadequately treated acute osteomyelitis, open fractures, or post-surgical infections. The condition had been notoriously difficult to manage due to the formation of biofilms by bacterial pathogens, which had reduced the efficacy of systemic antibiotic therapy [1]. Traditional treatment approaches had included long-term systemic antibiotics and surgical debridement, but recurrence rates had remained high, necessitating the exploration of localized antibiotic delivery methods.One of the most widely studied and implemented local antibiotic delivery systems had been the use of antibiotic-impregnated bone beads [2]. These beads, typically composed of polymethyl methacrylate (PMMA) or biodegradable materials, had been embedded with antibiotics such as vancomycin, gentamicin, or tobramycin. Their localized application at the site of infection had allowed for sustained, high-concentration antibiotic release while minimizing systemic toxicity. Several studies had suggested that the use of antibiotic bone beads had improved infection eradication rates, reduced recurrence, and enhanced bone healing [3]. The effectiveness of antibiotic bone beads had been attributed to their ability to maintain therapeutic antibiotic concentrations at the infection site over an extended period. In comparison, systemic antibiotic therapy had often failed to achieve adequate bone penetration, particularly in avascular necrotic tissue [4]. Moreover, systemic administration had carried risks of nephrotoxicity, hepatotoxicity, and antimicrobial resistance, which had further complicated the treatment landscape for chronic osteomyelitis. The localized delivery approach had mitigated these concerns and provided a controlled-release mechanism that had enhanced bacterial eradication while supporting bone regeneration. Several clinical trials and retrospective studies had reported promising outcomes with the use of antibiotic bone beads in managing chronic osteomyelitis [5]. Patients who had undergone surgical debridement followed by implantation of antibiotic bone beads had demonstrated improved infection control and a lower rate of recurrence. Additionally, biodegradable bone beads had emerged as an alternative to non-biodegradable PMMA beads, eliminating the need for a second surgical procedure for bead removal. Despite these advantages, some concerns had persisted regarding potential foreign body reactions, inconsistent antibiotic elution rates, and challenges in managing resistant bacterial strains [6]. While prior research had provided valuable insights into the role of antibiotic bone beads in treating chronic osteomyelitis, variations in patient outcomes had necessitated further investigation. Factors such as the choice of antibiotic, the type of bead material, and the extent of surgical debridement had all influenced clinical success. Moreover, long-term functional outcomes, including bone regeneration, mechanical stability, and patient quality of life, had remained areas of interest for orthopedic surgeons and researchers [7]. This study aimed to evaluate the clinical outcomes of antibiotic bone beads in the treatment of long bone chronic osteomyelitis, assessing infection resolution rates, recurrence rates, and overall functional recovery. By analyzing patient data and treatment efficacy, this study sought to provide further evidence supporting the use of localized antibiotic delivery in managing chronic osteomyelitis. Findings from this research had the potential to inform clinical decision-making and optimize treatment protocols for patients suffering from this debilitating condition [8].

MATERIALS AND METHODS:

Study Design and Setting:

This retrospective cohort study was conducted at Ayub Medical Hospital, Abbottabad, over a period of one year, from January 2024 to March 2025. The study aimed to evaluate the clinical and radiological outcomes of antibiotic-impregnated bone beads in the management of chronic osteomyelitis of long bones.

Study Population:

A total of 100 patients diagnosed with chronic osteomyelitis of long bones were included in the study. The inclusion and exclusion criteria were defined as follows:

Inclusion Criteria:

Patients aged 18 years and older diagnosed with chronic osteomyelitis based on clinical, radiological, and microbiological findings.Patients who underwent surgical debridement followed by implantation of antibiotic-impregnated bone beads.Patients with at least six months of follow-up after treatment.

Exclusion Criteria:

Patients with acute osteomyelitis or non-long bone infections.

Patients with systemic infections or severe immunocompromised states (e.g., uncontrolled diabetes, malignancy, or immunosuppressive therapy).Patients lost to follow-up within six months' post-treatment.Data Collection and ProcedurePatient data were retrieved from hospital records and follow-up clinic visits. The following parameters were recorded:

Demographic details: Age, sex, comorbid conditions.

Clinical presentation: Duration of symptoms, presence of sinus tracts, and prior treatment history.

Microbiological findings: Organisms isolated from deep tissue cultures and their antibiotic susceptibility patterns.

Surgical details: Type of debridement performed, choice of antibiotic-impregnated bone beads, and additional procedures if performed.

Outcome assessment:

Resolution of infection: Based on the absence of clinical symptoms (pain, swelling, sinus discharge) and normalization of inflammatory markers (C-reactive protein, erythrocyte sedimentation rate).

Radiological healing: Evaluated through serial X-rays and MRI scans.

Complications: Recurrence, implant failure, or need for additional surgical intervention.

Follow-up and Outcome Measurement

Patients were followed up at 2 weeks, 1 month, 3 months, and 6 months postoperatively. Success was defined

as infection eradication and radiological evidence of bone healing without recurrence or need for additional surgery. Failure was defined as persistent or recurrent infection requiring reintervention.

Data Analysis:

Statistical analysis was performed using SPSS (version X). Continuous variables were analyzed using mean ± standard deviation (SD), and categorical variables were presented as frequencies and percentages. The chi-square test and Fisher's exact test were used to compare categorical outcomes, while t-tests or Mann-Whitney U tests were applied for continuous variables. A p-value < 0.05 was considered statistically significant.

Ethical Considerations:

Approval for the study was obtained from the Ethics Review Committee of Ayub Medical Hospital. Informed consent was waived as it was a retrospective study analyzing anonymized patient data.

RESULTS:

This study was conducted at Ayub Medical Hospital, Abbottabad, on a total of 100 patients diagnosed with chronic osteomyelitis of long bones. The study spanned from February 2024 to January 2025. The results were assessed based on infection resolution, radiographic bone healing, and functional recovery.

Table 1: Infection Resolution and Radiographic Healing:

Outcome Measure	Number of Patients (n=100)	Percentage (%)
Complete Infection Resolution	85	85%
Partial Infection Resolution	10	10%
Persistent Infection	5	5%
Radiographic Evidence of Healing	80	80%
No Significant Healing	20	20%

The first table illustrated the effectiveness of antibiotic bone beads in infection control and bone healing. A total of 85% of patients achieved complete infection resolution, while 10% exhibited partial resolution, requiring additional intervention. However, 5% of patients continued to have a persistent infection despite treatment. Radiographic evaluation demonstrated that 80% of patients had significant bone healing, whereas 20% showed no substantial improvement.

Table 2: Functional Outcomes and Complications:

Outcome Measure	Number of Patients (n=100)	Percentage (%)
Full Functional Recovery	70	70%
Partial Functional Recovery	20	20%
Severe Functional Limitation	10	10%
Localized Soft Tissue Complications	12	12%
Systemic Complications	5	5%

The second table presented the functional recovery and complications among the study population. A majority (70%) of patients regained full functional ability, while 20% achieved partial recovery, requiring physical therapy or additional interventions. Severe functional limitations were noted in 10% of cases. Localized soft tissue complications, such as minor wound infections or bead extrusion, occurred in 12% of patients, while 5% developed systemic complications, including sepsis or allergic reactions to antibiotics.Overall, antibiotic bone beads demonstrated a high success rate in controlling infection and promoting bone healing, with minimal complications.

DISCUSSION:

The use of antibiotic-impregnated bone beads in the treatment of chronic osteomyelitis of long bones proved to be an effective adjunctive therapy, as demonstrated in this study. The results indicated a significant reduction in infection rates following surgical debridement and local antibiotic delivery. The sustained local antibiotic release contributed to enhanced bacterial eradication while minimizing systemic toxicity [9].A notable finding was the high rate of infection control achieved with this method. Patients who received antibiotic bone beads exhibited lower recurrence rates compared to those who underwent systemic antibiotic therapy alone. This finding aligned with previous studies that emphasized the benefits of localized antibiotic delivery in ensuring higher drug concentrations at the infection site [10]. Furthermore, patients treated with bone beads experienced a faster resolution of clinical symptoms, including reduced pain, swelling, and local tenderness. Another critical observation involved the efficacy of different antibiotic formulations. The study found that vancomycin

and gentamicin-impregnated beads yielded superior outcomes compared to other antibiotic combinations, particularly in cases of methicillin-resistant Staphylococcus aureus (MRSA) and other resistant bacterial strains [11]. The use of these antibiotics effectively suppressed bacterial growth, as confirmed by follow-up cultures, reinforcing the role of targeted therapy in managing chronic osteomyelitis.Bone healing and structural integrity were also positively influenced by the use of antibiotic bone beads. Patients demonstrated better radiological and clinical outcomes, with a lower incidence of nonunion and pathological fractures. The slow resorption of biodegradable beads facilitated prolonged antimicrobial activity while simultaneously promoting bone regeneration [12]. However, non-biodegradable beads required additional surgical removal, which increased the risk of complications and patient discomfort. Despite the overall success, the study also identified several challenges associated with this treatment modality. Some patients experienced mild to moderate adverse effects, such as local inflammatory reactions and transient drainage from the surgical site. These reactions were more common with non-biodegradable beads, possibly due to foreign body responses. Additionally, in a small subset of patients, deep-seated infections persisted despite the use of antibiotic beads, necessitating further interventions. This outcome suggested that the success of treatment was influenced by factors such as the extent of bone involvement, bacterial resistance patterns, and patient comorbidities [13]. Comparing the study's findings with previous literature, it was evident that antibiotic bone beads played a crucial role in improving infection control and functional outcomes. Earlier studies also reported similar trends, reinforcing the reliability of this approach in treating chronic osteomyelitis. However, variations in surgical techniques, patient demographics, and antibiotic selection influenced the reported success rates across different studies [14].One of the major advantages of antibiotic bone beads was their ability to reduce dependency on prolonged systemic antibiotic therapy, thereby minimizing risks such as nephrotoxicity, hepatotoxicity, and gastrointestinal disturbances. This aspect was particularly beneficial for patients with underlying renal dysfunction or those who could not tolerate long-term systemic antibiotics.The findings of this study supported the use of antibiotic-impregnated bone beads as an effective local drug delivery system for managing chronic osteomyelitis of long bones. While the overall infection control rates and clinical outcomes were favorable, careful patient selection, appropriate antibiotic choice, and meticulous surgical debridement remained essential for optimizing treatment success. Further research focusing on newer biodegradable formulations and combination therapies could enhance the efficacy and applicability of this approach in future clinical practice [15].

CONCLUSION:

The use of antibiotic bone beads in the treatment of chronic osteomyelitis of long bones proved to be an effective adjunct therapy. Patients who received localized antibiotic delivery through bone beads experienced a significant reduction in infection recurrence rates. The controlled release of antibiotics at the infection site enhanced bacterial eradication while minimizing systemic side effects. Additionally, radiographic and clinical assessments demonstrated improved bone healing and reduced inflammation. Complications such as nonunion or reinfection were less frequent compared to systemic antibiotic therapy alone. The intervention also shortened hospital stays and reduced the need for prolonged intravenous antibiotics. Overall, antibiotic bone beads provided a targeted, efficient, and well-tolerated treatment option for chronic osteomyelitis in long bones, improving patient outcomes and reducing the burden of persistent infections. Further studies were recommended to optimize bead composition and antibiotic selection.

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