Original article

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Role of Biodegradable Cement in Musculoskeletal Infection in the Pediatric Population

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Abstract

Introduction: Chronic osteomyelitis presents a significant challenge when it comes to treatment in children. Despite thorough radical debridement and extended antibiotic courses, it often proves resistant to resolution. The literature lacks definitive guidelines on the optimal management of chronic osteomyelitis, leaving several unanswered questions.

Patients and methods: The study comprised all patients who underwent surgery in the year 2022. After clinical history, examination, radiological studies, and blood investigations; single stage debridement and bone cement beads application was performed and patients were followed up for a period of 12 months.

Result: Eighteen patients (12 males and 6 females) with a mean age 6 years requiring surgical debridement were included in the study. Involved bones were tibia (12%), ulna (6%), humerus (6%), and femur (76%). Erythrocyte sedimentation rate (ESR) normalized in a mean time of 2.3 months and C-reactive protein (CRP) normalised in a mean time of 2.3 weeks. The average duration of infection prior to treatment was 5.6 months (Table 2). The most common organism isolated was Methicillin Resistant Staphylococcus aureus (MRSA) (Table 4) and most common antibiotic sensitivity found was with Linezolid (58%) followed by Vancomycin (41%). Mean bone healing time radiologically was 3.3 months and mean cement absorption time was 2.6 months.

At 1 year follow up, all patients had healing both clinically and radiologically. There was reactivation of infection in 1 patient that got settled with antibiotic therapy only. None of the children in the series required reoperation for infection at 1 year follow up.

Conclusion: The addition of biodegradable cement increases the rate of eradication of infection during treatment of chronic osteomyelitis in children. Antibiotic course should be continued until the ESR and CRP normalise with an initial short intravenous course.

Keywords: Chronic osteomyelitis, Stimulan, Paediatric

Introduction

Infections are a common occurrence in children, and many can be effectively treated in a primary care setting. However, it is essential to acknowledge that certain infectious like osteomyelitis and septic arthritis conditions necessitate the expertise of an orthopaedic surgeon.

Chronic osteomyelitis presents a significant challenge when it comes to treatment in the paediatric population. Despite thorough radical debridement and extended antibiotic courses, it often proves resistant to resolution. The literature lacks definitive guidelines on the optimal management of chronic osteomyelitis, leaving a number of questions unanswered [1]. These include the appropriate duration and route of antibiotic administration, the potential benefits of local antibiotic delivery

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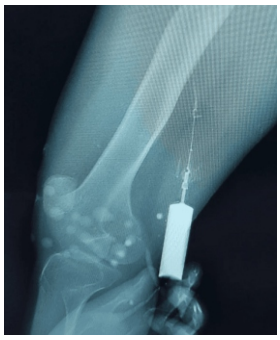

Figure 1: Sinogram

Figure 2: Antibiotic impregnated biodegradable cement

systems, the feasibility of using artificial bone grafts and whether reaming the canal can play a role in treatment [2]. The absence of clear guidelines highlights the complexity and need for further research in addressing this challenging condition in children.

Therefore, our study endeavours to explore chronic osteomyelitis management in long bones, considering the use of local antibiotic delivery systems, to contribute to a more comprehensive understanding of this challenging medical condition.

Material and method

The study comprised eighteen children between 4 and 15 years of age. This was a case series in which all patients were followed for a period of 1 year, with a focus on those who had undergone surgical procedures during the year 2022. All procedures performed were in accordance with the ethical board standards of the institution. Informed consent was obtained from the parents or carers. Data collected were demographic details, site of infection, etiology of infection, surgical procedure, and the causative organism.

After obtaining a detailed history and examination, all patients underwent anteroposterior (AP) and lateral radiograph of the respective site with blood markers in the form of complete blood count, erythrocyte sedimentation rate (ESR) and C reactive protein (CRP) preoperatively. Deep culture from pre-existing sinus tract was also obtained to add an appropriate antibiotic in the cement according to culture and sensitivity reports (Fig. 3).

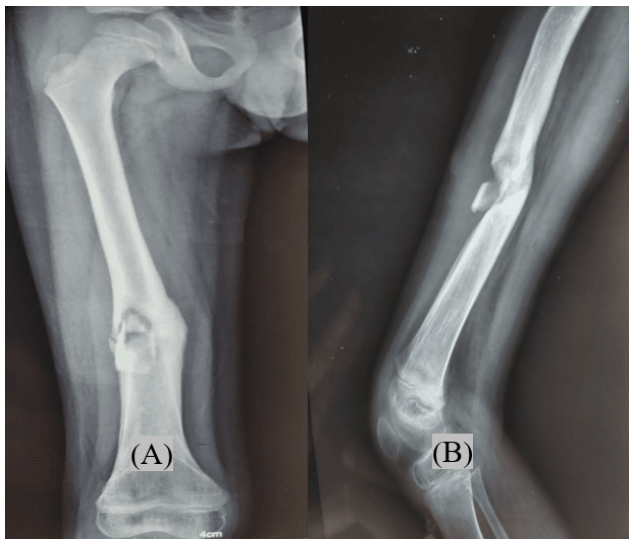

Figure 3: Preoperative radiographs
A, B: Pre-operative radiographs (AP and lateral) of right femur showing Inhomogeneous osteosclerosis andsequestrum formation (necrotic bone)

After completing preoperative evaluation, all patients underwent single stage debridement of necrotic bone and soft tissue. Patients in whom a sinus tract was present underwent sinogram and sinus tract removal. After performing a radical debridement, reaming of the medullary canal was done in patients having type 4 Cierny Mader chronic osteomyelitis. (Fig. 1) Antibiotic impregnated biodegradable calcium sulphate pellets (Stimulan®, Biocomposites, UK) were prepared according to the defect.

The biodegradable cement has two parts namely a powder and a solvent. 1 gram of vancomycin powder was mixed thoroughly with the powder along with 240 mg of gentamycin till a smooth mixture was formed. The mixture was spread over a bead mat according to requirement of bead size and was left untouched for 5 min (Fig. 2). After washing the wound with 6-9 L normal

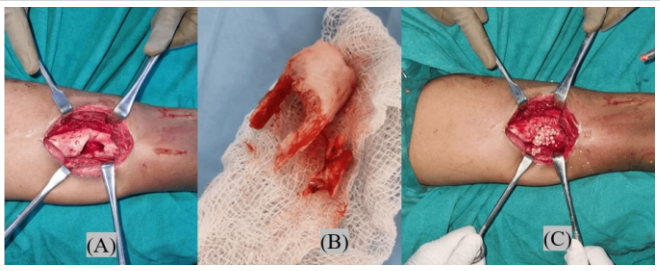

Figure 4: A, B: Intraoperative images showing removal of sequestrum (necrotic bone)
C: Intraoperative images showing application of the antibiotic impregnated biodegradable cement beads in and around the infected bone post curettage

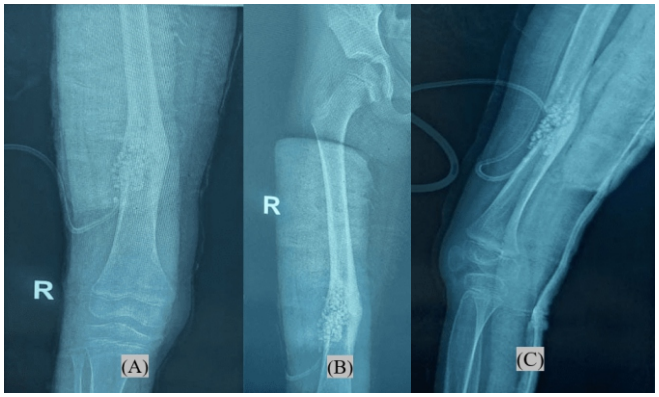

Figure 5: A,B,C: Post-operative radiographs (AP and lateral) of right femur showing the removal of sequestered bone and antibiotic impregnated biodegradable cement beads in and around the infected bone

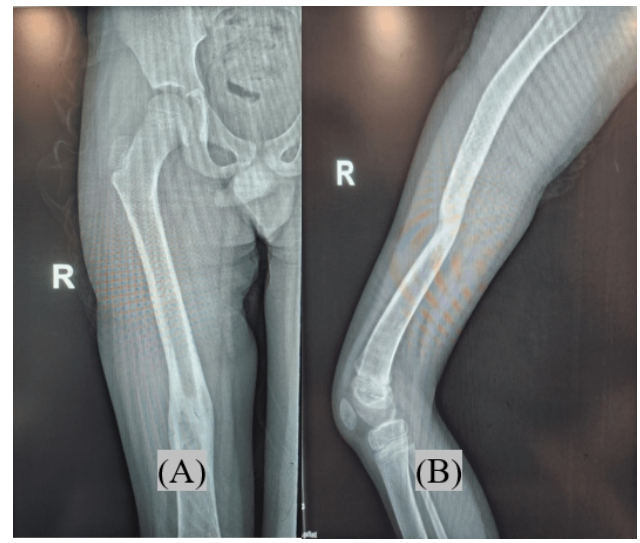

Figure 6: A, B: 1 year follow-up radiographs (AP and lateral) of right femur showing the union of the femur with no sign of chronic osteomyelitis

saline, the preformed pellets were inserted in the bone and the wound closed in layers. If required, splintage in the form of a slab was applied.

All the samples i.e. the sequestrum and infected tissue were sent for culture, gram stain, acid-fast bacilli stain and CBNAAT for Mycobacterium tuberculosis (Fig. 4). Empirical intravenous amoxicillin was administered after intraoperative specimens were collected for bacteriology and continued till the culture report was available. Intravenous antibiotics according to sensitivity were administered during the inpatient stay and the patient was discharged on oral antibiotics (Fig. 5).

Postoperative dressing was performed on day 2 of surgery. On days 3 and 5, repeat ESR and CRP were sent to confirm a downward trend. The patient was discharged on post op day 5 after relook dressing, if there was no discharge from the surgical site and ESR/CRP were decreasing. Patients were called after 2 weeks for suture removal; oral antibiotics were continued till ESR/ CRP normalised and all signs of active infection subsided. Subsequently, the children were followed up monthly for 3 months and then 3-monthly for 1year. Complete healing of the osteomyelitis was deemed to have occurred when there was resolution of pain, normalization of inflammatory parameters, and radiographic improvement of bone (Fig. 6).

Result

Eighteen patients consisting of 12 males and 6 females, (mean age 6 years) (Table 1) requiring surgical debridement were included in the study. Involved bones were tibia (12%), ulna (6%), humerus (6%), and femur (76%) (Table 2). Average duration of infection was found to be 5.6 months (Table 2). According to the Cierny-Mader classification system, there was 10 stage I (medullary osteomyelitis), 5 stage III (localized osteomyelitis), and 3 stage IV (diffuse osteomyelitis) lesions. Our study comprised of 2 locally and/or systemically compromised (B) hosts and fifteen normal hosts (A). (Table 3) The most common organism isolated was MRSA (35%) (Table 4) and most common antibiotic sensitivity found was with linezolid (58%) followed by vancomycin (41%) (Table 4). Mean radiological bone healing time was found to be 3.3 months and mean cement absorption time was found to be 2.6 months (Table 5). ESR normalized in a mean time of 2.3 months and CRP returned to normal values within a mean period of 2.3 weeks (Table 6) Only 1 patient had recurrence in the form of local pain and redness after 6 months with no radiological sign of infection. ESR and CRP normalized after 1 month of oral antibiotic therapy accompanied by complete resolution of symptoms.

At 1 year follow up, 100 percent patients had healing both clinically and radiologically with 94 percent showing no signs of relapse. None of the patients in the series underwent reoperation.

Table 1 : showing the gender distribution and age at the time of presentation

Years	Gender
5.2	Male
6.4	Female
6.8	Male
4.9	Female
5.7	Male
6.2	Male
5.6	Male
6.9	Male
7.3	Male
5.8	Female
6.5	Male
6.3	Male
6	Female
5.4	Male
5.9	Female
6.7	Female
6.6	Male
5.1	Male

Table 2 : showing the infected bones,the duration of infection at the time of presentation,immunological status of the patient

Site	Infection duration (months)
Humerus	12
Femur	6
Femur	5
Distal femur	8
Femur	4
Femur	12
Tibia	1
Femur	6
Femur plus leg	1
Femur	1
Femur	4
Ulna	14
Femur	10
Femur plus iliac	3
Femur	4
Leg	3
Ilium	5
Femur	3

Table 3: showing Cierny-Mader classification

Immunological status	Cierny-Mader classification
Immunocompetent	Stage 1
Immunocompromised	Stage 4
Immunocompetent	Stage 1
Immunocompromised	Stage1
Immunocompetent	Stage1
Immunocompetent	Stage1
Immunocompetent	Stage3
Immunocompetent	Stage3
Immunocompromised	Stage1
Immunocompetent	Stage1
Immunocompetent	Stage3
Immunocompetent	Stage3
Immunocompromised	Stage4
Immunocompetent	Stage1
Immunocompetent	Stage3
Immunocompetent	Stage1
Immunocompetent	Stage 1
Immunocompetent	Stage4

Table 4 : showing organism isolated following bacterial culture and antibiotioc sensitivity to the respective organism

Intraoperative culture Organism	Antibiotic sensitivity postoperative	Sinus tract culture (seen in 5 patients)	
MRSA	Linezolid	-	-
MRSA	Linezolid, vancomycin, clindamycin	MRSA	Vancomycin, linezloid
Coag negative staph aureus	Meropenem, linezolid	-	-
Sterile	-	-	-
Sterile	-	-	-
Sterile	-	-	-
MSSA	Vancomycin, linezolid, clindamycinmssa	-	-
MRSA	Linezolid	MRSA	Linezloid plus vancomycin
Pseudomonas	Gentamycin, vancomycin, clidamycin	Pseudomonas	Vancomycin
			Gentamicin
Sterile		MRSA	Vancomycin
Klebsella	Amoxicillin,piptaz	-	-
Pseudomonas	Amikacin, gentamycin, piptaz, amoxicillin	-	-
MRSA	Linezolid,vancomycin, clindamycin	-	-
MRSA	Linezloid , vancomycin	-	-
MRSA	Amikacin, linezolid, ciprofloxacin	-	-
MSSA	Amoxicillin, linezolid	-	-
Pseudomonas	Piperacillin, tazobatum, imipenem, amoxicillin	MRSA	Vancomycin, linezloid
MRSA	Vancomycin, linezolid, clindamycin	-	-

Discussion

Our study primarily centres on the management of chronic osteomyelitis in long bones. Chronic osteomyelitis is typically managed by a combination of surgery and chemotherapy. However, the process of deep debridement in bone, although essential, creates voids that may necessitate the use of bone grafts or bone cement, potentially introducing further concerns [3].

Another concern is the requirement for prolonged systemic antibiotic therapy. Both systemic and local antibiotic delivery methods have demonstrated success in eradicating residual bacteria [4]. Nonetheless, prolonged systemic antibiotic administration is not without drawbacks, being associated with additional cost and the risk of systemic adverse effects, such as nephrotoxicity and gastrointestinal discomfort [5]. Another challenge is of achieving adequate local antibiotic concentration in areas affected by ischemia due to vascular damage within infected bones. Moreover, limited biofilm penetration further complicates the management of chronic osteomyelitis [6].

In light of these challenges, there has been a shift in the focus of antibiotic therapy toward the utilization of local delivery systems [7]. This approach allows for the attainment of high antibiotic concentrations at the site of infection, effectively addressing symptoms and treating chronic osteomyelitis, while minimizing the systemic side effects associated with injectable form, as demonstrated by Zhang et al. in 2010 [3]. This strategy holds significant promise in providing effective management for chronic osteomyelitis.

Surgeons routinely utilise polymethyl methacrylate (PMMA) cement with local antibiotic but this requires a second surgery for removal of the cement spacer. PMMA also acts as a substrate for further bacterial colonization when antibiotic release declines over time and finally becomes ineffective. The available evidence strongly suggests that the use of bio-absorbable calcium sulphate can potentially result in a reduction in the number of surgical procedures required and a decrease in surgical complications when treating chronic osteomyelitis [8]. Furthermore, it maintains a high success rate in eradicating infections, as referenced in recent literature.

Table 5 : showing the bone healing time and cement absorption time with the mean bone healing time radiologically was found to be 3.3 months and mean cement absorption time was found to be 2.6 months

Healing time Months	Cement absorption Months
3	3
3.5	3
3	2.5
2	2
4	2.5
4	3.5
4	2.5
5	2
5	2
2	2.5
3	3
2	2.5
4	2.5
3	2.5
3	3
3	3
3	3
3	3

Table 6 : showing the mean time of normal time of ESR normalisation in 2.3 months and CRP normalisation in a mean time of 2.3 weeks

ESR normalise (in months)	CRP normalise(in weeks)
2	2
2	2
2	2
2.5	2
2	3
2.5	3
1.5	3
1.5	2
3	2
2	3
1.5	2
2	3
2	2
2	2
2.5	2
2	3
3	2
2.5	2

These studies have reported infection eradication rates ranging from 86% to 100% and bone healing rates in the range of 87.5% to 100% [9].

We have demonstrated the role of biodegradable cement in osteomyelitis and its benefit over conventional cement. All the patients in this series demonstrated good healing with 94% having no relapse at 1 year follow up. There was no need for prolonged IV antibiotic therapy. Patients could be discharged on oral antibiotics which were continued till resolution of symptoms and inflammatory markers.

Conclusion

Biodegradable cement enhances the healing potential in management of chronic osteomyelitis in children.

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Declaration of patient consent : The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given the consent for his/ her images and other clinical information to be reported in the journal. The patient understands that his/ her names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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