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Research Article

The Use of Antibiotic-Impregnated Cement in the Surgical Treatment of Chronic Osteomyelitis in Children

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Abstract

Aim: Information in the literature related to paediatric chronic osteomyelitis is extremely limited as the disease can be prevented to a large extent in developed countries. The aim of this study was to evaluate the clinical and radiological results of patients treated with two-stage surgical debridement and antibiotic-impregnated cement because of chronic osteomyelitis, and to thereby contribute to the literature.

Material and Method: Two-stage surgical debridement and antibiotic-impregnated cement was performed because of chronic osteomyelitis in 8 patients (6 males, 2 females) with a mean age of 6 years (range, 2-11 years) between June 2018 and June 2022. Demographic data were recorded together with the time since the onset of symptoms, anatomic localisation, accompanying fractures, and laboratory parameters. Postoperatively, the patients were followed up in respect of infection recurrence, nephrotoxicity, and fracture healing with direct radiographs and laboratory tests.

Results: The mean follow-up period was 19 months (range, 12-30 months). The localisation of chronic osteomyelitis was determined to be the femur in 2 (25%) patients, the tibia in 3 (37%), the humerus in 2 (25%), and the radius in 1 (12%). In 3 (37%) patients with no history of trauma, the diagnosis made on first evaluation was osteomyelitis-related pathological fracture. No recurrence of infection was observed in any patient during the follow-up period after the final surgery. Full bone union was observed in the cases with accompanying fracture, and of these, deformity was determined in 2 and mild contracture in 1.

Conclusion: Paediatric chronic osteomyelitis can lead to severe problems of bone integrity, especially in cases which have been neglected or when presentation is delayed. Despite predictable complications, the application of antibiotic-impregnated cement may be effective in the context of providing infection eradication and bone union, which are the main treatment aims in this disease.

Keywords: Pediatric, chronic osteomyelitis, surgical treatment, antibiotic-impregnated cement

INTRODUCTION

Chronic osteomyelitis (CO) in the pediatric population is defined as a bone infection characterised by necrotic bone formation, lasting longer than 3 months. This prolonged form of osteomyelitis disease occurs due to neglect of or insufficient treatment of the acute and subacute forms of osteomyelitis caused by pyogenic organisms (1). The incidence data are limited in current literature related to this clinical condition, which is currently seen as a problem in under-developed countries. There are also insufficient studies in the literature related to the surgical treatment of chronic osteomyelitis which leads to severe complications in children due to the protracted clinical course and frequent recurrences (2,3).

The aim of this study was to present the clinical and radiological results of patients treated in a tertiary-level healthcare centre in East Africa with two-stage surgical debridement and antibiotic-impregnated cement because of chronic osteomyelitis, and to thereby contribute to the literature.

CITATION

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MATERIAL AND METHOD

Patients

Ethics Committee approval was obtained for this descriptive, retrospective study (decision no: 846, dated: 07.09.2023). A total of 12 paediatric patients were applied with surgical debridement and antibiotic-impregnated cement for a diagnosis of chronic osteomyelitis between June 2018 and June 2022 in the Mogadishu Somalia Türkiye Recep Tayyip Erdoğan Training Research Hospital. The study included 8 of these patients (6 males, 2 females) with a mean age of 6 years (range, 2-11 years) who had sufficient clinical and radiological follow-up data. In addition to the demographic information of age and gender, a record was also made of the time since the onset of symptoms, anatomic localisation, accompanying fractures, and laboratory parameters. For the radiological evaluations in the diagnosis of the patients, anteroposterior and lateral radiographs of the involved extremity were obtained, and if necessary, magnetic resonance imaging (MRI) and computed tomography (CT) were performed.

Surgical Procedure

A two-stage surgical procedure was applied to the patients. In the first stage, following fluoroscopic checking of the focus in the involved extremity, a skin incision was made including the fistula tract when necessary, then the bone cortex was reached with debridement of the surrounding soft tissue. Corticotomy windows were opened at a size appropriate to the dimensions of the intramedullar necrotic bone tissue, and sequestered bone tissues were curetted. The debrided soft tissues and bone tissues were sent for pathological and microbiological examinations. After irrigation of the surgical area with physiological saline, antibiotic-impregnated cement was applied according to the width of the defective intramedullar canal and the surrounding soft tissue. To prepare the antibiotic-impregnated cement, 40mg liquid gentamicin was mixed with 40gr polymethylacrylate bone cement (4). In cases where there was no bone defect, an appropriate number of pellets with diameter of approximately half a centimetre obtained from this mixture were placed in the intramedullar bone region and surrounding soft tissue area where debridement was made. Especially in cases with accompanying fracture and bone defect, the antibiotic-impregnated cement was applied in a single piece to function as a spacer according to the size of the bone defect (Figure 1). Also in these cases with accompanying fracture, fixation was applied with an additional external fixator or intramedullar Kirschner wire, then the first stage was terminated with primary closure of the wound sites. In cases where infection could be discounted with clinical and laboratory parameters during the follow-up, the second stage of surgery was perfomed by entering through the same incision lines and the antibiotic-impregnated cement pellets were removed (Figure 2) and in cases with an accompanying fracture, fixation was renewed. In the second stage, grafting was not performed because no serious bone defects were observed. The time interval between the surgical stages was recorded.

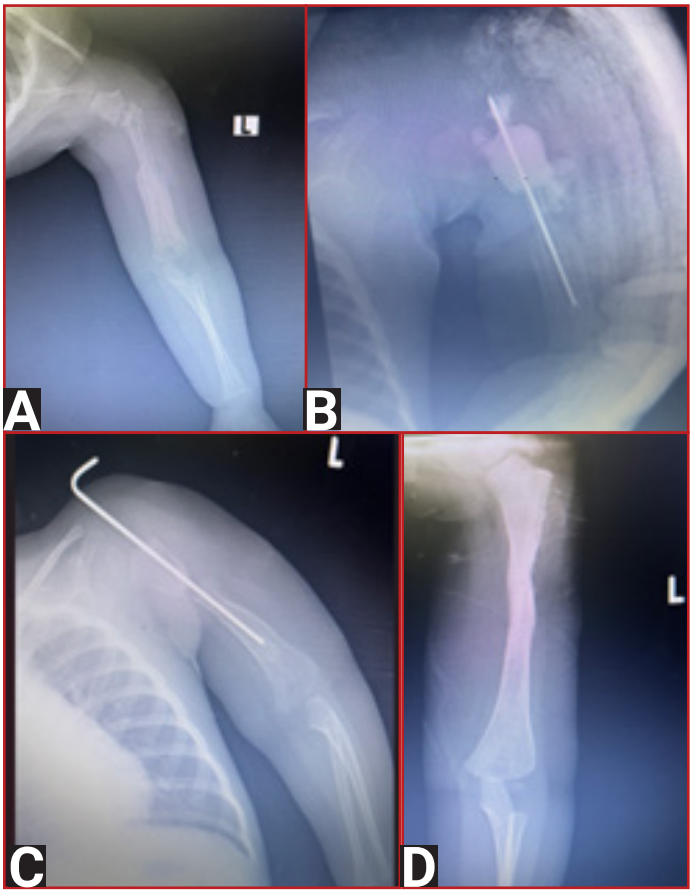

Figure 1. Case 7: (**A**) first diagnosis of a 2-year-old female with chronic osteomyelitis and accompanying pathological fracture in the left humerus, (**B**) first-stage application of antibiotic-impregnated cement spacer, (**C**) second-stage removal of the spacer and re-fixation, (**D**) direct radiographs at the final follow-up examination

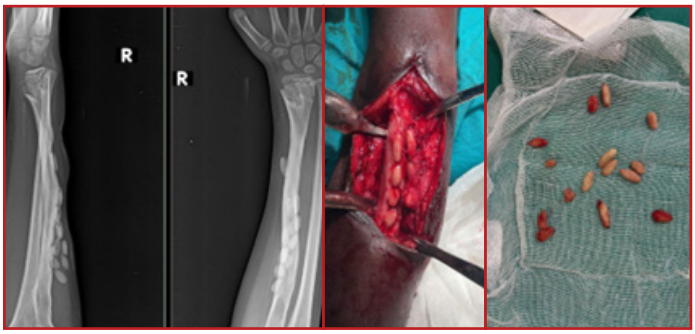

Figure 2. Case 6: A 9-year-old male with chronic osteomyelitis in the right radius shaft and a history of distal radioulnar trauma; direct radiograph before the second stage and removal of the antibiotic-impregnated pellets

Follow-Up

After the surgery, intravenous broad-spectrum antibiotherapy was initiated for all the patients. The patients were followed up in the hospital for intravenous biotherapy of mean 13 days (range 6-25 days) according

to the micro-organism identified in the culture, and after discharge from hospital, oral treatment was continued for mean 4 weeks (range, 2-6 weeks). In the clinical follow-up, the patients were followed up in respect of infection recurrence, nephrotoxicity, and fracture healing with direct radiographs and laboratory tests.

RESULTS

Before presentation at the hospital, none of the patients had undergone surgery or received intravenous antibiotherapy treatment, and the duration of symptoms was mean 5.7 months (range, 4-8 months). In this period, patients had complaints of difficulty in using the involved extremity, pain, sensitivity, swelling, and fever. Fistula formation was observed in 5 (62%) patients. The localisation of chronic osteomyelitis was determined to be the femur in 2 (25%) patients, the tibia in 3 (37%), the humerus in 2 (25%), and the radius in 1 (12%). According to the anamnesis obtained from the family, there was a history of trauma in 4 (50%) patients. In 1 (10%) of these patients, conservative treatment had been applied after an acute fracture. In 3 (37%) patients with no history of trauma, the diagnosis made on first evaluation was osteomyelitis-related pathological fracture. In all the patients, there were elevated values of white blood cells, C-reactive protein, and sedimentation rate (Table 1).

Table 1. Demographics and clinical characteristic of children at the time of inital examination

Case	Age (years)	Duration of symptoms (months)	History	Location	Fracture	Laboratory data WBC (10^3/µl) / ESR (mm/h) / CRP (mg/l)
1	8	6	Trauma	Femur	No	13.800 / 73 / 89
2	6	8	Trauma	Tibia	Yes	11.560 / 60 / 54
3	2	5	-	Tibia	Yes	15.200 / 26 / 72
4	11	4	-	Humerus	No	8.080 / 72 / 55
5	5	7	-	Femur	Yes	12.750 / 58 / 48
6	9	6	Trauma	Radius	No	14.840 / 83 / 79
7	2	4	-	Humerus	Yes	10.250/ 55 / 74
8	5	6	Trauma	Tibia	No	15.330 / 98 / 92

CRP: C-reactive protein, ESR: eritrocyte sedimentation rate, WBC: white blood cell

The data related to the treatment and follow up of the patients are presented in Table 2. The culture results were reported as no production in 3 (37%) patients and the identifiable organisms were Staphylococcus aureus (37%), Methicillin-resistant Staphylococcus aureus (12%), and Streptococcus pyogenes (12%). No findings of tumour were determined in the pathological examinations of the patients and no nephrotoxicity was observed in any patient during the follow-up.

Table 2: Overview of treatment and follow-up

Case	Causative organism	Antibiotics	Duration of IV antibiotics (days)	Duration of oral antibiotics (weeks)	Interval between stages (weeks)	Follow-up (months)
1	Staphylococcus aureus	Amoxicillin/clavulanic acid + teicoplanin	6	6	15	12
2	Negative	Teicoplanin + piperacillin/tazobactam	25	6	12	14
3	Negative	Amoxicillin/clavulanic acid + teicoplanin	20	4	20*	20
4	Staphylococcus aureus	Amoxicillin/clavulanic acid + teicoplanin	12	4	9	18
5	Negative	Amoxicillin/clavulanic acid + teicoplanin	8	4	16*	17
6	Staphylococcus aureus	clindamycin + rifampicin	14	2	15	16
7	MRSA	Vancomicin + meropenem	13	3	14*	28
8	Streptococcus pyogenes	Clindamycin + rifampicin	7	6	13	30

IV: intravenous, MRSA: Methicillin-resistant Staphylococcus aureus, *: re-operation between and/or after stages

The time interval between the surgical stages was mean 14 weeks (range, 9-20 weeks). Fixation of an accompanying fracture in the first stage was made with intramedullar Kirschner wire in 3 patients (Cases 2, 3, and 7) and with an external fixator in 1 (Case 5). In these 4 cases, the cement was removed in the second-stage surgery, and fixation was

re-applied with intramedullar Kirschner wire. Additional debridement was performed once between the surgical stages in 1 patient (Case 2).

The mean follow-up period was 19 months (range, 12-30 months). No recurrence of infection was observed in any patient during the follow-up period after the final surgery. No limb length discrepancy or loss of range of movement in the adjacent joint was observed in any of the patients without accompanying fracture.

Full Bone

union was observed in the cases with accompanying fracture. In the final evaluations of these cases, tibia varum was determined in 1 patient (Case 2) (Figure 3), tibia valgum in 1 patient (Case 3), and mild contracture in the shoulder joint of 1 patient (Case 7).

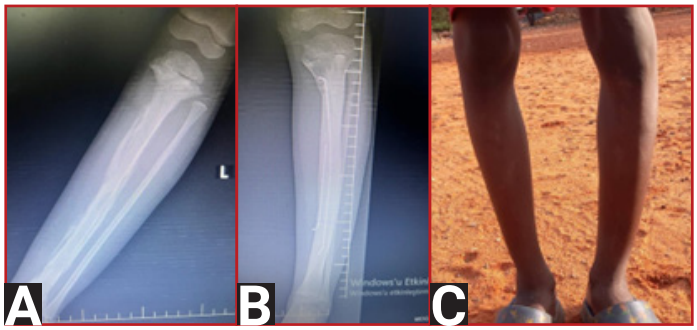

Figure 3. Case 2: A 6-year-old male with chronic osteomyelitis accompanied by fracture of the left tibia; (**A**) first evaluation, (**B**) after completion of treatment, (**C**) varus deformity seen on radiographs

DISCUSSION

There is extremely limited information in the literature related to paediatric chronic osteomyelitis (CO) and the surgical treatments of this. Current medical modalities which allow rapid diagnosis and treatment in early sites of acute inflammation that has developed through hematogenous spread or direct inoculation are extremely effective in preventing osteomyelitis becoming chronic (5). In contrast, the presence of CO continues to be a significant medical problem which must be dealt with in geographic regions with limited access to basic healthcare facilities. Although the incidence of osteomyelitis has been reported to be 80 per 100,000 in low-income countries, there are no data related to the extent of progression to the chronic stage (6). Moreover, in the sources where it is mentioned, CO is usually seen as a multifocal recurrent autoinflammatory entity or as a complication secondary to previous surgery, whereas all the current study cases were all untreated primary prolonged inflammation.

Although CO includes symptoms and findings similar to those of acute pyogenic osteomyelitis, such as fever, pain, swelling, and inability to use the affected extremity, continuation of the clinical condition throughout a 3-6-month period is important in respect of time-dependent definition in the differentiaton from subacute osteomyelitis. The condition forming the basis of time-dependent differentiation is the development of bone necrosis that can be seen without doubt radiologically (7). The cases in the current series had complaints ongoing for a period of up to approximately 6 months and had radiological findings that could be observed on direct radiographs. Moreover, the diagnosis was supported by MRI when necessary and by elevated values of white blood cells, C-reactive protein, and sedimentation rate.

Generally, aggressive debridement of necrotic bone and soft tissue with antibiotherapy form the basic treatment principle in all cases of CO (8). In the adult population, the application of antibiotic-impregnated cement to the surgical area after debridement is one of the frequently applied treatment methods (9). Studies showing the use of this method in paediatric cases are extremely limited in number. Paley (10) and Bar-On (11) reported that infection was safely eradicated using a two-stage surgical method with gentamicin-impregnated cement rods after intramedullar reaming. However, the patients in those series were relatively older children. In the current study patients, the intramedullar canal width was narrow because of their young age, so to avoid creating an iatrogenic fracture, the method of intramedullar reaming was not preferred. In another study, Andreacchio et al. (12) applied tobramicin-impregnated calcium sulphate to 12 skeletally immature CO patients. However, it is not possible to provide spacer support with the properties of these calcium sulphate beads in patients with accompanying fracture and bone defect. Furthermore, to be able to open a serous drainage route from the incision area after the application of bio-absorbable bone substitutes such as calcium sulphate can constitute a risk in respect of wound healing (13,14).

The basic aim of applying local antibotherapy through cement or bio-absorbable bone substitutes is to avoid the toxicity that can be created by the doses of systemic drugs required to provide the desired level of antibiotic concentration in the surgical field. In contrast to the many studies reporting the safety of local application of antibiotics, there are also data in the literature showing that administration of ≥4gr vancomycin or >1gr aminoglycoside can create toxicity (15-17). As not all the prepared antibiotic-impregnated cement was used in the current cases, it is not possible to state the net amount of antibiotic applied locally. However, no notable findings of nephrotoxicity were encountered in any patient during the follow-up period.

In the microbiological examinations, no agent could be determined in 3 patients (Cases 2, 3, 5), while the predominance of methicillin-sensitive Staphylococcus Aureus observed in the other cases was consistent with the literature (18). Although the duration of intravenous antibiotherapy in the current series was relatively shorter than that of similar studies (11,12) because of the hospital and cost conditions observed, it was considered

appropriate to continue with oral treatment after discharge for patients with a decrease of >50% in C-reactive protein levels after the first stage of surgery and no wound site complications (19). Additional debridement was only performed on one patient (Case 2) as sufficient clinical and laboratory improvement was not seen, and the duration of intravenous antibiotherapy in this patient was relatively longer.

Paediatric osteomyelitis is important both in terms of treatment difficulties and orthopaedic complications. The most important of these are subperiosteal abscess in which the surrounding soft tissue is also affected, avascular necrosis, deformities, limb length discrepancy, and bone defects formed after pathological fractures (20). The current study can be considered of great importance as it included cases with a pathological fracture in the basis of CO, for which the main reason is undoubtedly the delayed presentation of the patients and the lack of or insufficiency of basic treatment facilities during that period.

Although full bone union was able to be obtained in all the patients with no recurrence of infection, all the patients who had varying degrees of deformity and contracture during the follow-up period were seen to be the children with an accompanying primary or pathological fracture.

There were some limitations to this study, primarily that the low number of cases prevented statistical evaluations. The study subject of the two-stage antibiotic-impregnated cement technique was performed based on the preference of the surgeon, and no data were available of an alternative technique for the purposes of comparison. Complications that could be observed as a result of the treatment were included in the follow-up period, and for complications which may be observed in the long-term, a longer follow-up period is needed.

CONCLUSION

Paediatric CO occurring because of insufficient treatment of acute osteomyelitis in cases that have been neglected or that present late can lead to severe problems of bone integrity. Despite predictable complications, the application of antibiotic-impregnated cement may be effective in the context of providing infection eradication and full bone union, which are the main treatment aims in this disease.

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Conflict of interest: *The authors have no conflicts of interest to declare.*

Ethical approval: *This study was carried out with the scope of the approval and information of Mogadishu Somalia Türkiye Recep Tayyip Erdoğan Training Research Clinical Research Ethics Committee (Date and Decision No: 07.09.2023 and 846).*

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