ORIGINAL ARTICLE

Prognosis and outcome of exogenous bacterial osteomyelitis: A prospective cohort study

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ABSTRACT

Background and Objectives: Exogenous osteomyelitis frequently follows traumatic or surgical inoculation of bacteria into bone and surrounding tissue. It is usually associated with open fractures, surgical implants, orthopaedic fixation devices and vascular insufficiencies such as diabetes mellitus, peripheral vascular diseases and presence of foreign bodies. The aim of this study was to identify the pathogenic bacteria causing osteomyelitis and to evaluate the prognosis and outcome of patients with exogenous osteomyelitis. **Materials and Methods:** Patients admitted with clinical and radiological features of exogenous osteomyelitis were selected for the study from June 2005 to October 2006. Bone curettings or aspirated materials from the sinus tract were collected. The specimens were cultured on appropriate media for bacterial culture. The patients who consented were followed up for 6 months to record their progress and outcome. Those followed up included both culture positives and negatives. **Results:** Out of 125 cases of osteomyelitis, 75 (60%) were positive by culture, 59 (78.7%) were monomicrobial infections and 16 (21.3%) were polymicrobial infections. *Staphylococcus aureus*, 56 (60.8%) in number, was the predominant organism isolated followed by *Escherichia coli,* eight (8.7%); *Klebsiella pneumoniae,* seven (7%); *Pseudomonas aeruginosa,* five (5.4%); β-haemolytic streptococci, four (4.4%); *Proteus mirabilis,* three (3.2%); *Enterococcus faecalis,* two (2.2%); *Acinetobacter baumannii,* two (2.2%); *Corynebacterium jeikeium,* one (1.1%); *Staphylococcus epidermidis,* one (1.1%); *Proteus vulgaris*, one (1.1%); Kingella species one (1.1%) and Arcanobacterium species, one (1.1%). Out of the coagulase-positive staphylococci, 29 (51.8%) were Methicillin-resistant *S. aureus*. Of the 61 cases that were followed up, 44 cases were culture positive. The total cure rate was 60.2%. **Conclusion:** Appropriate antibiotic therapy after culture and sensitivity has a major role in treating exogenous osteomyelitis in the presence of fracture and instability of bone. In spite of appropriate surgical correction, the major risk factors that led to recurrence of infections and amputations were overcrowding in wards, extensive tissue injury, poor economic status of patients, non-availability of drugs in the hospital pharmacy, poor compliance of patients and drug toxicity.

Key words: Amputation, bone curettings, exogenous osteomyelitis, Methicillin-resistant *Staphylococcus aureus*, orthopaedic implant

INTRODUCTION

Osteomyelitis is defined as infection of bone. It is a heterogeneous disease in its pathophysiology, clinical presentation and management. It is very difficult to treat among all the infectious diseases.[1,2] Exogenous osteomyelitis frequently follows traumatic or surgical inoculation of bacteria into bone and surrounding tissue, in contrast to acute haematogenous osteomyelitis which is caused by bacteraemia. It is usually associated with open fractures, surgical implants, orthopaedic fixation devices, total joint implants and vascular insufficiency such as diabetes, peripheral vascular diseases and presence of foreign bodies. Exogenous osteomyelitis is commonly seen in adults beyond their teens and is chronic in nature, whereas acute haematogenous osteomyelitis is seen in children. Management of exogenous osteomyelitis includes surgical debridement, skeletal stabilisation, dead space management, soft tissue coverage, identification of the causative organisms and pathogen-directed antimicrobial therapy. The prompt management of infection based on

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culture and sensitivity helps in clinical cure, preventing chronicity, hospital stay and complications such as amputations.

MATERIALS AND METHODS

Objectives

- Identification of the pathogenic bacteria causing exogenous osteomyelitis
- To evaluate the prognosis and outcome of patients with exogenous osteomyelitis.

This is a prospective cohort study conducted in the Department of Microbiology, Government Medical College, Thiruvananthapuram, Kerala, in association with the Department of Orthopaedics, Medical College Hospital, Thiruvananthapuram, Kerala, from June 2005 to October 2006.

Inclusion criteria

Patients older than 20 years with clinical and radiological features of exogenous osteomyelitis following trauma or surgery were included in the study. Persistent bone pain, erythema, swelling and pus discharge localised to an area of previous trauma, surgery and wound infection were the clinical criteria for diagnosis of osteomyelitis. Radiological criteria for diagnosis of osteomyelitis were osteopenia, thinning of the cortices, loss of the bone architecture, sequestra formation seen as more radiodense area relative to the normal bone.

Exclusion criteria

Patients below 20 years, those suffering from vertebral osteomyelitis and immunosuppressive diseases such as leukaemia, lymphoma and tumours, were excluded from the study.

Using these criteria, selected patients were closely followed up for 6 months. Patients with no signs and symptoms of exogenous osteomyelitis on follow-up were considered as 'cured'. Patients with signs and symptoms of exogenous osteomyelitis not responding to antibiotics during follow-up were considered as 'recurrence'. Performa was filled for each patient regarding the clinical details and investigation done. Written informed consent was obtained from all the patients.

Specimens collected were bone curettings or aspirated materials from sinus tract. Bone curettings were collected per-operatively under general anaesthesia in a sterile wide-mouthed container. Sinus tract aspirate was collected under local anaesthesia after cleaning the site with sterile normal saline and then aspirating the pus using a syringe and needle. After collection of the samples, the specimens were transported to the laboratory and processed without delay. Bone curettings were ground using pestle and mortar. Gram stain was done and the specimens were inoculated on 5% sheep blood sugar, MacConkey agar, salt agar, chocolate agar, glucose broth and Robertson's cooked meat broth. Alkaline pyrogallol was used to create anaerobic environment.

Antibiotic susceptibility of isolates was done by disc diffusion. All Staphylococcus strains were phage typed at Moulana Azad Medical College, New Delhi. Culture reports were issued and the patients were followed up for 6 months.

RESULTS

A total of 125 patients satisfying the inclusion and exclusion criteria were selected in the study. Out of these, 70 cases (66.6%) belonged to the active age group (20–39 years) [Table 1] and 111 cases (88.8%) were males. Out of the 125 cases, 122 cases (97.6%) were fracture associated [Figure 1]. Others were due to needle prick injury and multiple osteosis with diabetes mellitus. There was one case of Hansen's disease. Of the 125 cases studied, in 113 cases (90.4%), bones of the lower limb were affected. Among the lower limb bones, femur was the most common bone involved (51.2%). Of the 122 cases of fracture associated osteomyelitis, the number of closed fracture with internal fixator was 89 (72.7%) while open fractures with external fixation was 33 (27.3%) [Table 2]. Among

Table 1: Distribution of cases according to age

Age in years	Number of cases (%)
20-29	38 (30.4)
30-39	32 (25.6)
40-49	25 (20.0)
50-59	13 (10.4)
60-69	12 (9.6)
70-79	4 (3.2)
80-89	1 (0.8)
Total	125 (100)

Table 2: Relationship between bones involved, the type of fracture and implant used

Bone involved	Number of closed fracture with internal fixator (%)	Number of open fracture with external fixator (%)
Femur	54 (44.2)	10 (8.2)
Tibia	17 (13.9)	6 (4.1)
Both bone-lower limb	7 (5.7)	11 (9.0)
Ankle	2 (1.6)	5 (3.2)
Both bone-upper limb	2 (1.6)	-
Radius	1 (0.8)	-
Mandible	1 (0.8)	-
Humerus	5 (4.0)	1 (0.8)
Total	89 (72.7)	33 (27.3)

122 fracture associated cases, 113 cases were due to road traffic accidents and nine cases were due to fall.

A total of 125 specimens were collected. The most frequent mode of collection was sinus tract aspiration. Out of the 125 cases studied, 75 cases (60%) were culture positive while the rest were bacteriologically sterile [Figure 2]. Gram stain showed the presence of pus cells and organism in all the culture positives.

Microbial profile

Out of the 75 culture positive cases, 59 cases (78.3%) were monomicrobial infections while 16 cases (21.6%) were polymicrobial infections. Out of the 59 monomicrobial infections, *Staphylococcus aureus* (42/59) was the predominant pathogen isolated [Table 3 and Figure 3]. Out of the 16 polymicrobial infections, *S. aureus* with multidrug-resistant (MDR) *Klebsiella pneumoniae* (4/16) and *S. aureus* with *Escherichia coli* (3/16) were the predominant pathogens [Table 4]. Out of 56 *S. aureus* isolated, 29 (51.8%) were Methicillin-resistant *S. aureus* (MRSA).

Out of 29 cases, MRSA was isolated as a single pathogen in 21 cases and along with other organisms such as *K. pneumoniae, Pseudomonas aeruginosa, E. coli, Proteus mirabilis* and *Enterococcus faecalis* in eight cases. Other important organisms include β-haemolytic streptococci, *Staphylococcus epidermidis, Corynebacterium jeikeium,* Kingella spp. and Arcanobacterium spp. Among the Gram-negative bacilli,

Table 3: Number of isolates according to frequency

Organisms	Number		Total (%)
	Pure	Polymicrobial	
S. aureus	21	6	27 (29.3)
MRSA	21	8	29 (31.5)
S. epidermidis	1	-	1 (1.1)
β-haemolytic streptococci	4	-	4 (4.4)
E. faecalis	-	2	2 (2.2)
C. jeikeium	1	-	1 (1.1)
Arcanobacterium spp.	-	1	1 (1.1)
E. coli	2	6	8 (8.7)
K. pneumoniae	2	5	7 (7.6)
P. aeruginosa	4	1	5 (5.4)
P. mirabilis	1	2	3 (3.2)
P. vulgaris	-	1	1 (1.1)
Acinetobacter baumannii	1	1	2 (2.2)
Kingella spp.	1	-	1 (1.1)
Total	59	33	92

S. aureus: *Staphylococcus aureus*; *S. epidermidis*: *Staphylococcus epidermidis*; *E. faecalis*: *Enterococcus faecalis*; *C. jeikeium*: *Corynebacterium jeikeium*; *E. coli*: *Escherichia coli*; *K. pneumonia*: *Klebsiella pneumonia*; *P. aeruginosa*: *Pseudomonas aeruginosa*; *P. mirabilis*: *Proteus mirabilis*; *P. vulgaris*: *Proteus vulgaris*; *A. baumannii*: *Acinetobacter baumannii*; MRSA: Methicillin-resistant *Staphylococcus aureus*; *K. pneumonia*: *Klebsiella pneumoniae*

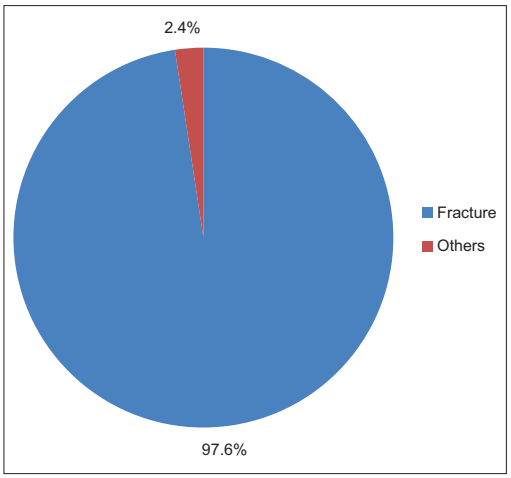

Figure 1: Causative factors of exogenous osteomyelitis

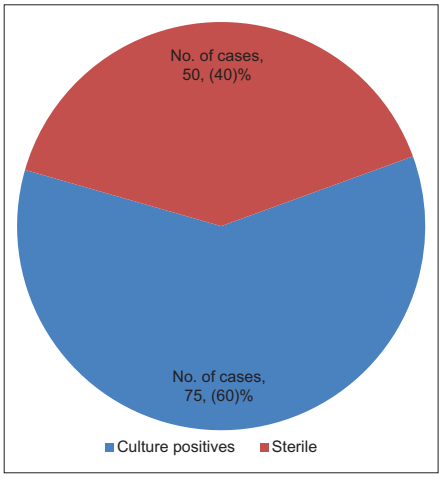

Figure 2: Exogenous osteomyelitis – culture positivity

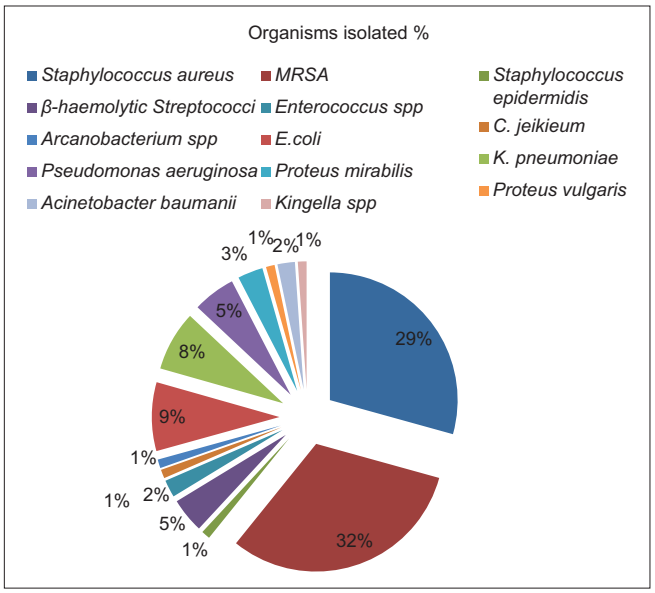

Figure 3: Organisms isolated %

Table 4: Polymicrobes isolated

Isolates	Number of cases from which isolated
MRSA + *K. aerogenes* (MDR)	4
S. aureus + *K. aerogenes*	1
MRSA + *E. coli* (MDR)	1
MRSA + *E. coli*	1
S. aureus + *E. coli*	3
S. aureus + *A. baumannii*	1
MRSA + *P. mirabilis*	1
E. faecalis + *P. vulgaris*	1
S. aureus + Arcanobacterium spp.	1
MRSA + *E. faecalis* + *P. mirabilis*	1
K. aerogenes (MDR) + *P. aeruginosa*	1
Total	16

S. aureus: *Staphylococcus aureus*; *E. faecalis*: *Enterococcus faecalis*; *K. pneumonia*: *Klebsiella pneumonia*; *E. coli*: *Escherichia coli*; *P. vulgaris*: *Proteus vulgaris*; *P. mirabilis*: *Proteus mirabilis*; *P. aeruginosa*: *Pseudomonas aeruginosa*; *K. aerogenes*: *Klebsiella aerogenes*; MRSA: Methicillin-resistant *Staphylococcus aureus*; MDR: Multidrug resistant; *A. baumannii*: *Acinetobacter baumannii*

the predominant isolate was *E. coli* (8.7%). Anaerobic organisms were not isolated from any case [Tables 3 and 4].

Antibiotic sensitivity pattern

Among the 27 isolates of Methicillin-sensitive *S. aureus* (MSSA), all (100%) were resistant to Penicillin. Among the 29 isolates of MRSA, all (100%) were sensitive to Vancomycin, Clindamycin and Linezolid. Among the four isolates of β-haemolytic streptococci, all (100%) were sensitive to Penicillin and the two isolates (100%) of *E. faecalis* were sensitive to Ampicillin and Erythromycin. The single isolate *C. jeikeium* was sensitive to Vancomycin and Linezolid only [Table 5].

All the Gram-negative bacilli were sensitive to Imipenem, Cefoperazone-Sulbactam combination and Piperacillin-Tazobactam combination. No drug resistance was detected in Arcanobacterium spp. and Kingella spp [Table 6].

Phage typing of *S. aureus* revealed that the 25 strains were typable. Phage Group I was the most common and accounted for 52% of the isolates. Type 29/52A/79 was the most common type seen in Group I [Table 7].

Out of the 125 cases, 61 cases were followed for 6 months. Others could not be followed since they were lost to follow-up. Out of these 61 cases, 44 were culture positives and 17 cases were bacteriologically sterile. Out of 44 culture positive cases, in 27 (61.3%) cases, antibiotics and surgical management cleared the infection completely. Out of 17 bacteriologically sterile cases, 10 (58.8%) cases resolved completely. The total cure rate was (37/61) 60.7% [Table 8].

Out of 27 cured culture positive cases, amputation was needed for four (14.8%) cases. Implant removal was

Table 5: Antibiotic sensitivity pattern of Gram-positive organism isolated (% sensitive)

Organism (*n*)	Penicillin	Gentamicin	Erythromycin	Intermediate cephalosporin	Oxacillin	Amikacin	Vancomycin	Clindamycin	Rifampicin	Linezolid	Cotrimoxazole	Ampicillin
S. aureus (27)	0	77.7	74	100	100	100	100	100	100	100	NT	NT
MRSA (29)	0	0	0	0	0	41.4	100	100	89.6	100	NT	NT
S. epidermidis (1)	0	100	100	100	100	100	100	100	100	100	NT	NT
E. faecalis (2)	0	100 (I)	100	0	NT	NT	NT	NT	NT	NT	NT	100
β-haemolytic Streptococci (4)	100	100 (I)	100	100	NT	NT	NT	NT	NT	NT	NT	100
C. jeikeium (1)	0	0	0	0	NT	0	100	0	0	100	0	0
Arcanobacterium spp. (1)	100	100	100	100	NT	100	100	100	100	100	100	100

NT: Not tested; *S. epidermidis*: *Staphylococcus epidermidis*; *S. aureus*: *Staphylococcus aureus*; *E. faecalis*: *Enterococcus faecalis*; *C. jeikeium*: *Corynebacterium jeikeium*; MRSA: Methicillin-resistant *Staphylococcus aureus*

Table 6: Antibiotic sensitivity pattern of Gram-negative bacilli (% sensitive)

Organism (*n*)	Ampicillin	Gentamicin	Intermediate cephalosporin	Amikacin	Ciprofloxacin	III generation cephalosporin	Cefoperazone-Sulbactam	Piperacillin-Tazobactam	Imipenem
E. coli (8)	0	40	20	80	40	60	100	100	100
K. pneumoniae (7)	0	62.5	12.5	75	25	25	100	100	100
P. aeruginosa (5)	NT	80	NT	100	80	80	NT	100	100
P. mirabilis (3)	33.3	33.3	0	100	33.3	66.6	100	100	100
P. vulgaris (1)	0	0	0	0	0	0	100	100	100
A. baumannii (2)	50	100	50	100	50	50	100	100	100
Kingella spp. (1)	100	100	100	100	100	100	100	100	100

NT: Not tested; *E. coli*: *Escherichia coli*; *P. mirabilis*: *Proteus mirabilis*; *P. aeruginosa*: *Pseudomonas aeruginosa*; *P. vulgaris*: *Proteus vulgaris*; *A. baumannii*: *Acinetobacter baumannii*; *K. pneumonia*: *Klebsiella pneumoniae*

needed for seven cases (25.9%). All other cases were cured with surgical treatment and prolonged antibiotic therapy. Amputation was needed in case of MDR *P. mirabilis* infection, *S. epidermidis* infection, MRSA infection and in a case of polymicrobial infection caused by *Proteus vulgaris* and *E. faecalis*. Implant removal was needed in three cases of MRSA infection, two cases of *K. pneumoniae* infection, one case of *S. aureus* infection and in a case of polymicrobial infection with MRSA and MDR *K. pneumoniae* and in one bacteriologically sterile case [Table 9].

Out of 25 cases of *S. aureus* infections that were followed up, 8/10 cases of MSSA and 8/15 cases of MRSA were cured with antibiotics and surgical management, respectively. Among these, implant removal was needed in 3/15 cases of MRSA and 1/10 cases of MSSA infections. Amputation was needed in 1/15 case of MRSA infection.

Factors that led to early implant removal and amputations are illustrated in Figures 3 and 4.

DISCUSSION

This study provides an insight into the bacterial aetiology of exogenous osteomyelitis, the role that antibiotics play in the treatment schedule and outcome of cases.

In contrast to haematogenous osteomyelitis, the incidence of osteomyelitis due to direct inoculation or spread from a contiguous focus of infection is increasing.[3,4] This is probably due to motor vehicle accidents and the increasing use of orthopaedic fixation devices and total joint implants. Management of established osteomyelitis includes thorough debridement of necrotic tissue, stabilisation of bone, intraoperative tissue cultures, deadspace management with antibiotic beads, soft tissue coverage, limb reconstructive surgery and systemic antibiotic therapy. Despite many advances, osteomyelitis remains difficult to treat and the cure rates are still unsatisfactory. Although mortality has been eliminated, it often results in morbidity and disability. In addition to that, there are other quantifiable consequences, namely, time and money.[5]

Table 7: Results of phage typing of *Staphylococcus aureus*

n	Typable strains					Non-typable strains
	Group I	Group II	Group III	Mixed	Total	
Number of strains	13	0	4	8	25	20
Percentage	52	0	16	32	100	44

Table 8: Outcome of treatment after 6 months

Follow-up	Number of cases		Total (%)
	Culture positive	Sterile	
Total	44	17	61 (100)
Cured	27	10	37 (60.7)
Not cured	17	7	24 (39.3)

Table 9: Isolates in cured cases and treatment given

Organisms isolated	Treatment given		
	Antibiotics and surgical debridement	Implant removal needed	Amputation needed
MRSA (8)	4	3	1
MSSA (8)	7	1	Nil
S. epidermidis (1)	Nil	Nil	1
β-haemolytic Streptococci (4)	4	Nil	Nil
C. jeikeium (1)	1	Nil	Nil
K. pneumoniae (2)	Nil	2	Nil
P. mirabilis (1)	Nil	Nil	1
P. vulgaris + *E. faecalis* (1)	Nil	Nil	1
MRSA + MDR *K. pneumoniae* (1)	Nil	1	Nil
Total (27)	16	7	4

MRSA: Methicillin-resistant *Staphylococcus aureus*; MDR: Multidrug resistant; *S. epidermidis: Staphylococcus epidermidis; E. faecalis: Enterococcus faecalis; C. jeikeium: Corynebacterium jeikeium; P. mirabilis: Proteus mirabilis; P. vulgaris: Proteus vulgaris*; MSSA: Methicillin-sensitive *Staphylococcus aureus*

In this study, it was found that the most common age group affected is between 20 and 29 years (30.4%) and the next common age group affected is between 30 and 39 years (25.6%). This probably reflects the facts that adults and adolescents using motor vehicles are more prone for road traffic accidents due to their rash driving. Luca Lazzirine *et al.* report that males have a higher rate

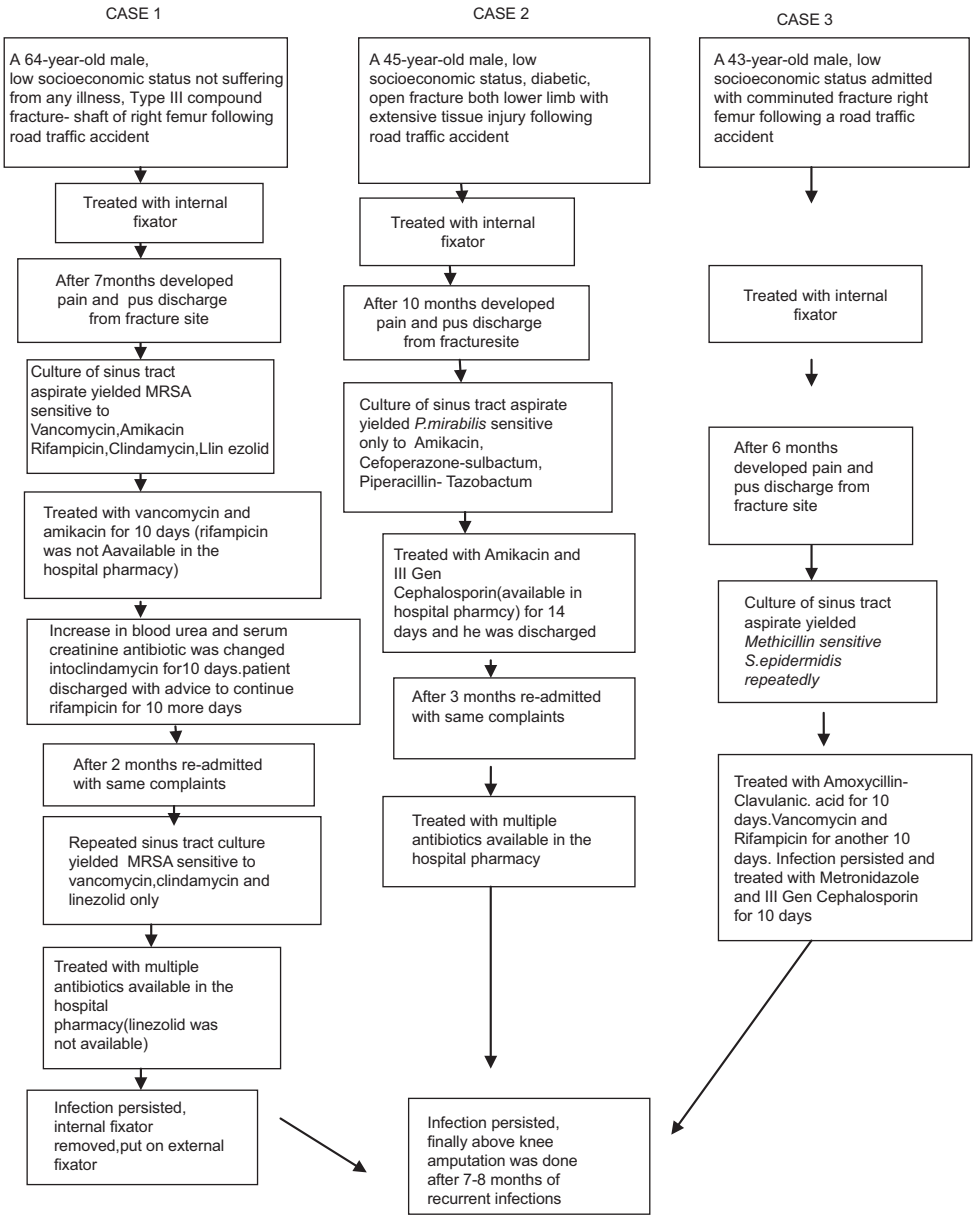

Figure 4: Factors leading to amputation-clinical scenario of three cases

of contiguous focus infection than do females.[6] In this study also, males are more (88.8%) commonly affected by exogenous osteomyelitis than females (11.2%). This may be due to the fact that motor vehicles are more commonly used by males than females and are prone to accidents.

According to this study, the most common cause of exogenous osteomyelitis is fracture, i.e., 97.6% of cases. In the present study, out of the 122 cases of fracture associated exogenous osteomyelitis, 113 (97.6%) cases were due to road traffic accidents.

Lew *et al.* and Salvana *et al.* report that contaminated open fractures can lead to the development of osteomyelitis of the fractured bone typically at the fractured site in 3–25% of cases.[7] The significant risk factors in their study were type of fracture, level of contamination, degree of soft tissue injury whether local or systemic therapy have been administered.

However, in the present study, all (100%) exogenous osteomyelitis complicating fracture was implant associated. Of these cases, 89 (72.7%) cases were associated with internal fixator and 33 cases (27.3%) cases were associated with external fixator. In an animal study by Soontoon Vipar and Necas *et al.*, post-operative bacterial osteomyelitis was a recognised complication following fracture and can be influenced by the presence of metallic implants. Factors that should be considered when using metallic implants include antibiotic prophylaxis, appropriate

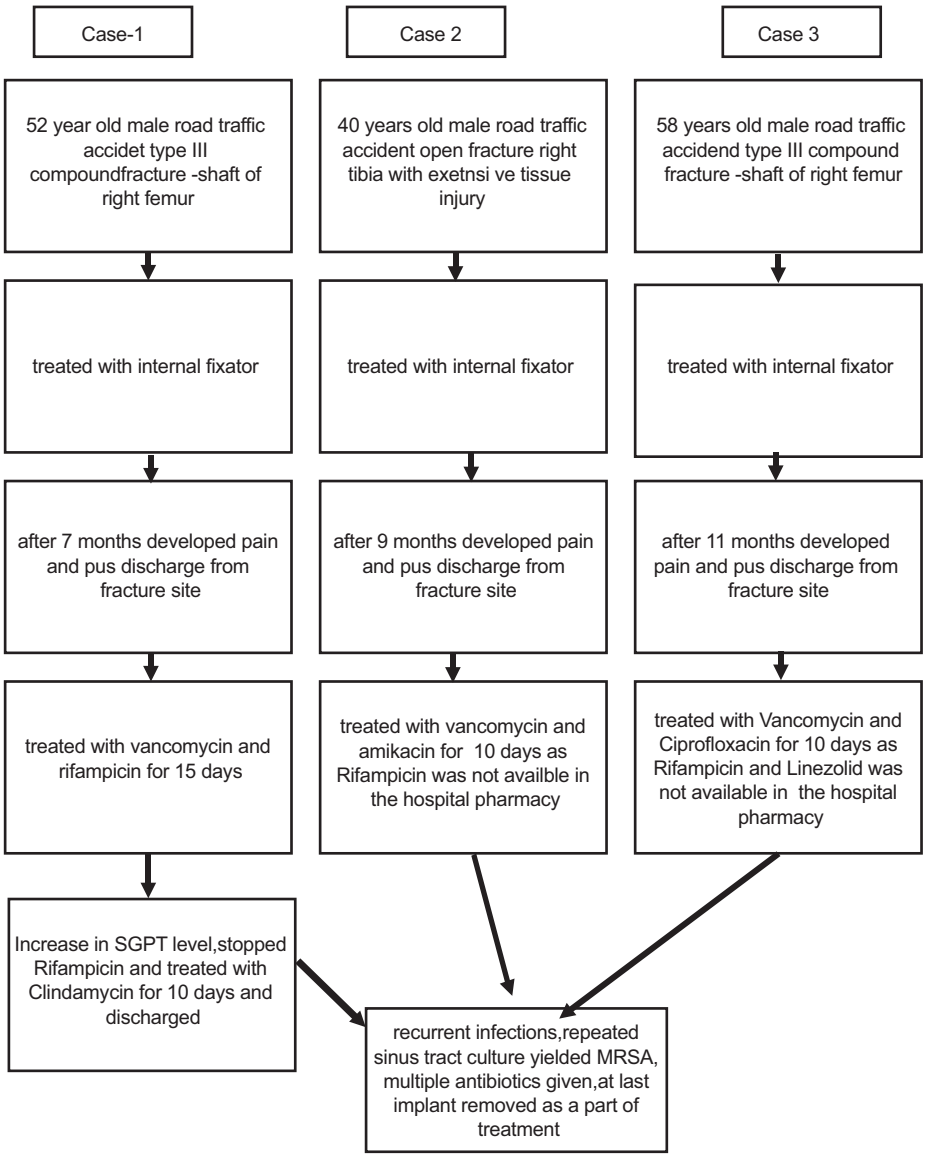

Figure 5: Factors leading to implant removal- "three cases of MRSA osteomyelitis"

implant selection, meticulous surgical technique and proper aseptic 'technique'. These results are similar to the study by Lew *et al*.[4]

Several studies report that the definitive diagnosis of exogenous osteomyelitis is by isolating the bacteria from the intra-operative biopsy specimen of the involved bone.[8] In the present study, only seven specimens (5.6%) were bone curettings while the rest of the specimens were sinus tract aspirates. There are many difficulties in getting bone curettings. First, the procedure has to be done under general anaesthesia. Second, in the presence of fracture or instability of the bone or joint, it is not advisable to take bone curetting as a part of diagnostic procedure. Third, most of the patients are not willing to do a diagnostic procedure under general anaesthesia.

In this study, 60% of the cases were culture positive. This does not mean that the sterile cases were not infected. Majority of these cases were referred from peripheral hospitals and were already on antibiotics which might have affected the culture results.

Several studies on the bacteriology of exogenous osteomyelitis are in accordance with the observation of the present study.[9] This distribution should be recalled when selecting antibiotic coverage for the patient with presumed post-traumatic infection.

In the present study, *S. aureus* was the major pathogen causing exogenous osteomyelitis.[10,11] All these cases were implant associated and in all these cases surgery was done to fix the fracture. Direct introduction of the pathogen to

the fractured site cannot be ignored. Majority were MRSA, and spread from other patients and health-care workers has to be considered. It is well known that strict aseptic techniques and hand-washing techniques can control this type of infections to a great extent.

P. aeruginosa is also a common pathogen in this study (5.4%). It can cause exogenous osteomyelitis after an open or a closed fracture after surgical procedure.[12] A pure culture of *P. aeruginosa* would be indicative of a true infection. In the present study, 4/5 isolates of *P. aeruginosa* were obtained as the sole pathogen and this was correlated with a direct Gram-stained smear.

β-haemolytic streptococci is also reported as a cause of exogenous osteomyelitis in several studies[5,13] In the present study also, 5.6% of the cases were due to β-haemolytic streptococci.

Several studies report coagulase negative staphylococci as a major pathogen in implant associated and post-traumatic osteomyelitis.[14,15] However, in the present study, *S. epidermidis* was isolated from a single case and was Methicillin sensitive.

No Penicillin-sensitive staphylococci were isolated in this study.

Among MRSA isolates, 58.6% isolates showed resistance to Amikacin. Rifampicin resistance was seen in 10.4% of MRSA isolates. It was seen that all these Rifampicin resistant cases were previously treated with Rifampicin alone and not with combination therapy. None of the MRSA was resistant to Vancomycin, Clindamycin and Linezolid.

None of the Gram-negative isolates were resistant to Cefoperazone-Sulbactam combination, Piperacillin-Tazobactam combination and Imipenem.

In the present study, *C. jeikeium* was isolated from both bone curettings and sinus tract aspirate. Gram stain showed pus cells and Gram-positive bacilli. It was sensitive only to Vancomycin and Linezolid. It was a case of Type III compound fracture right tibia due to road traffic accident one year back, put on external fixator admitted with swelling and pain, pus discharge from fracture site for two month duration and treated with parenteral Cloxacillin, Cefotaxime and Cefoperazone-Sulbactam combination. *C. jeikeium* is a cause of severe infections in hospitalised patients. This organism has been reported to cause post-surgical infections, peritonitis in patients undergoing chronic obstructive pulmonary disease, liver abscess, osteomyelitis and prosthetic joint infections. In the present study, the risk factors favouring *C. jeikeium* infection may be the presence of implant, hospitalisation for two months with recurrent infections, treatment with broad spectrum antibiotics and impaired skin integrity due to the presence of external fixator.[16]

Follow-up for 6 months

Sixty-one cases were followed up for 6 months. These cases included 44 culture positive cases and 17 bacteriologically sterile cases. Out of 44 culture positive cases, 27 cases were cured with antibiotics and surgical treatment. Out of 17 bacteriologically sterile cases, 10 cases were cured. Total cure rate was 60.7%. Among 44 culture positive cases, 15 were due to MRSA. Eight of these cases were cured with a combination therapy of Vancomycin and Amikacin, Clindamycin and Rifampicin, Rifampicin and Linezolid, Clindamycin alone, Vancomycin and Rifampicin. The treatment given was parenteral therapy for 10 days followed by 2–3 weeks of outpatient oral therapy. Implant removal was needed in three cases of MRSA. Amputation was needed in a single case of MRSA. Recurrence of infection was seen in seven cases of MRSA infections. In the present study, in the case of fracture associated osteomyelitis, appropriate antibiotic therapy appeared to have a major role in the treatment in the presence of fracture instability and implant. However, sample size for follow-up was not adequate for a proper conclusion.

Among 10 cases of MSSA, the treatment given were combination therapy, i.e. Cloxacillin and Gentamicin parenterally/Cloxacillin and Amikacin parenterally or Cloxacillin alone parenterally for 10 days followed by Cloxacillin orally for two weeks. Among these, eight cases were cured, but infection persisted in two cases. Implant removal was needed as a part of treatment in one of these cured cases. Amputation was not done in any of MSSA cases.

Amputation was needed as a part of treatment in 4 (14.8%) cases. The organisms isolated in these cases were MRSA, MDR *P. mirabilis, S. epidermidi*s and mixed growth of *P. vulgaris* and *E. faecalis*.

All the cases of β-haemolytic streptococci associated osteomyelitis resolved with crystalline Penicillin and Gentamicin therapy for 10 days followed by prolonged oral Amoxycillin therapy. No implant removal or amputation was needed.

In the present study, *C. jeikeium* associated osteomyelitis resolved with a combination of parenteral Vancomycin and oral Linezolid for 12 days followed by oral Linezolid for 10 days.

Swiontkowski *et al*. conducted a study in which they treated 93 patients of chronic osteomyelitis with combined surgical debridement, soft tissue coverage and an antibiotic regimen of 5–7 days of intravenous therapy followed by oral antibiotics for six weeks. They compared the outcome of these patients with those of a group of 22 patients treated previously with the same surgical management, but with six weeks of cultures-specific intravenous antibiotics. There was no difference in the outcome of these two groups. Hence, it is evident that the long-term administration of intravenous antibiotics is not necessary to achieve a high rate of clinical resolution.[17]

Among 17 bacteriologically sterile cases followed up, 10 cases recovered. These 10 cases were empirically treated with a combination of Cefuroxime and Metronidazole/Clindamycin or crystalline Penicillin and Cefotaxime and Metrogyl for 2–3 weeks parenterally followed by prolonged oral antibiotic therapy.

When this study was started, there was a high incidence of MRSA infection in orthopaedic wards [Table 10]. Dissemination from an MRSA infected wound because of ignorance on the part of house-surgeons and nurses handling the wounds in the ward could have been an important contributing factor to the spread of MRSA in the orthopaedic wards. This was brought to the notice of the head of the orthopaedics Department and the Medical Superintendent of the Hospital. Following measures were put into practice to control the spread of MRSA:

- Separate drums with sterile dressings and instruments are kept aside for patients infected with MRSA
- The house surgeons, nurses and other paramedical staff in orthopaedic wards were made aware of MRSA and the steps to be taken to prevent its spread
- Hand washing was strictly followed in between handling patients
- Appropriate and adequate antibiotic treatment was initiated according to the antibiotic sensitivity pattern of the pathogen isolated
- Adequate number of sterile gloves was made available in the wards and use of separate gloves for each patient was insisted.

It was not possible to isolate MRSA patients in our orthopaedic wards due to lack of space.

Table 10: Methicillin-resistant *Staphylococcus aureus* isolated from patients admitted in orthopaedic wards during the period June 2005 to October 2006

Month and year	Number of cases
January 2005	13
February 2005	11
March 2005	13
April 2005	9
May 2005	25
June 2005	14
July 2005	13
August 2005	7
September 2005	7
October 2005	6
November 2005	7
December 2005	9
January 2006	9
February 2006	10
March 2006	3
April2006	5
May 2006	6
June 2006	1
July 2006	3
August 2006	2
September 2006	2
October 2006	3
November 2006	3
December 2006	4

CONCLUSION

Despite all the advances in antibiotic and operative treatment, osteomyelitis remains difficult to treat with considerable morbidity and healthcare costs. This study shows that proper aseptic precautions and prompt antibiotic therapy based on culture and sensitivity can reduce the incidence of amputation and early implant removal in post-traumatic osteomyelitis. Healthcare professionals ranging from surgeons, microbiologists and nurses must work together and bring about a multidisciplinary approach in the management of osteomyelitis.

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REFERENCES

1. Browner BD, Levine AM, Jupiter JB, Trafton PG. Chronic osteomyelitis. A text book of skeletal trauma, basic science, management and reconstruction. Vol. 2. Saunders; 2003. p. 483-8.
2. Berbari EF, Steckelberg JM, Osman DR. Osteomyelitis. Mandell, Douglas and Bennet Principles and Practice of Infectious Diseases. 6th ed. vol.1. USA: Elsevier; 2005. p. 1322-32.
3. Lew DP, Waldvogel FA. Osteomyelitis. Current concepts. N Engl J Med 1997;337:428.
4. Available from: http:www.thelancet.com. [Last accessed on 2004 Jul 24].
5. Fang RC, Galiano RD. Adjunctive therapies in the treatment of osteomyelitis. Semin Plast Surg 2009;23:141-7.
6. Lazzirini L, Mader JT, Calhoun JH. Current concepts and Review. Osteomyelitis in Long Bones. The Journal of Bone and Joint Surgery 2004;86;2305-18.
7. Salvana J, Rodner C, Browner BD, Livingston K, Schreiber J,

Pesanti E. Chronic osteomyelitis: Results obtained by an integrated team approach to management. Conn Med 2005;69:195-202.
8. Nelson CL. Introduction. In: McCollister Evart C. Surgery of the Musculoskeletal System. 2nd ed. Edinburgh: Churchill Livingstone; 1994. p. 4299-300.
9. Cierny G 3rd. Classification and treatment of adult osteomyelitis. In: McCollister Evarts C. Surgery of the Musculoskeletal System. 2nd ed. Edinburgh: Churchill Livingstone; 1994. p. 4337-79.
10. Mayberry-Carson KJ, Tober-Meyer B, Smith JK, Lambe DW Jr., Costerton JW. Bacterial adherence and glycocalyx formation in osteomyelitis experimentally induced with *Staphylococcus aureus*. Infect Immun 1984;43:825-33.
11. Longo D, Kasper DL, Jameson JL, Fauci AS, Hauser SL, Loscalzo J. Osteomyelitis. Harrison"s principles of Internal Medicine.18th ed. vol. 1. McGraw Hill Education; 2011.
12. Pier GB, Ramphal R. *Pseudomonas aeruginosa*. Mandell, Douglas, and Bennet, Principles and Practice of Infectious Diseases. 6th ed., Vol. 2. USA: Elsevier; 2005. p. 2602-3.
13. Tice AD, Hoaglund PA, Shoultz DA. Risk factors and treatment outcomes in osteomyelitis. J Antimicrob Chemother 2003;51:1261-8.
14. Shanson DC. Bone and joint infections. Microbiology in Clinical Practice. 3rd ed. Oxford: Butterworth and Heinmann; 1999. p. 305-8.
15. Moreillon P, Yok-Aique, Philippe. *Staphylococcus aureus* [including Staphylococcal toxic shock]. Mandell, Douglas, and Benne, Principles and Practice of Infectious Diseases. 6th ed., Vol. 2. USA: Elsevier; 2005. p. 2321-4.
16. Winn WC Jr., Allen SD, Jauda WM. (ABMM). Introduction to Microbiology, Aerobic and Facultative Anaerobic Bacilli, Koneman's Color Atlas and Textbook of Diagnostic Microbiology. 6th ed. Philadelphia: Lippincott Williams & Wilkins; 2006. p. 807-8.
17. Swiontkowski MF, Hanel DP, Vedder NB, Schwappach JR. A comparison of short- and long-term intravenous antibiotic therapy in the postoperative management of adult osteomyelitis. J Bone Joint Surg Br 1999;81:1046-50.