ORIGINAL RESEARCH

Clinical Outcome following Management of Severe Osteomyelitis due to Pin Site Infection

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Received on: 13 July 2023; *Accepted on:* 22 March 2024; *Published on:* 06 May 2024

Abstract

Aim: This study has investigated cases of pin site infection (PSI) which required surgery for persistent osteomyelitis (OM) despite pin removal.

Materials and methods: Patients requiring surgery for OM after PSI between 2011 and 2021 were included in this retrospective cohort study. Single-stage surgery was performed in accordance with a protocol at one institution. This involved deep sampling, debridement, implantation of local antibiotics, culture-specific systemic antibiotics and soft tissue closure. A successful outcome was defined as an infection-free interval of at least 24 months following surgery.

Results: Twenty-seven patients were identified (the sites were 22 tibias, 2 humeri, 2 calcanei, 1 radius); about 85% of them were males with a median age of 53.9 years. The majority of infections (21/27) followed fracture treatment. Fifteen patients were classified as BACH uncomplicated and 12 were BACH complex. *Staphylococci* were the most common pathogens, polymicrobial infections were detected in five cases (19%). Seven patients required flap coverage which was performed in the same operation.

After a median of 3.99 years (2.00–8.05) follow-up, all patients remained infection free at the site of the former OM. Wound leakage after local antibiotic treatment was seen in 3/27 (11.1%) cases but did not require further treatment.

Conclusion: Osteomyelitis after PSI is uncommon but has major implications for the patient as 7 patients needed flap coverage. This reinforces the need for careful pin placement and pin site care to prevent deep infection. These infections were treated in accordance with a protocol and were not managed simply by curettage. All patients treated in this manner remained infection-free after a minimum follow-up of 2 years suggesting that this protocol is effective.

Clinical significance: Pin site infection is a very common complication in external fixation. The sequela of a chronic pin site OM is rare but the implications to the patient are huge. In this series, more than a quarter of patients required flap coverage as part of the treatment of the deep infection.

Keywords: Local antibiotics, One-stage surgery, Osteomyelitis, Pin site infection, Retrospective cohort study.

Strategies in Trauma and Limb Reconstruction (2024): 10.5005/jp-journals-10080-1607

Introduction

External fixation is a common utility for the treatment of long bone injuries or in orthopaedic limb reconstruction surgery.[1,2] Pin site infection (PSI) is the most common complication of external fixator use. A prolonged time in an external fixator makes a PSI almost inevitable but due to a lack of a clear definition of PSI and the difference in diagnostic criteria, reported incidences of PSI range from 1 to 100%,[3–7] Numerous studies have investigated methods for the prevention of PSI and the diagnostic criteria for PSI but a consensus has not been reached.[5,7–15]

Pin site infection usually presents as a superficial infection which can be treated conservatively. If a deep infection ensues this can lead to chronic osteomyelitis (OM).[16] Standard treatment for severe pin infections may be through removing or exchanging the involved pin or wire but more severe consequences might involve a discontinuation of frame treatment, increased morbidity and the need for future surgical interventions. The literature investigating OM after PSIs is scarce. Aside from one historical study, there is another recent case series published in 2022 which evaluated the treatment of OM following PSI.[17,18] These showed that the overall recurrence rate of infection is as high as 36%, which increases to 66% with Gram-negative organisms.

In this study, we aim to investigate cases of PSI requiring surgery due to persistent OM which had not resolved despite pin removal or discontinuation of external fixator treatment.

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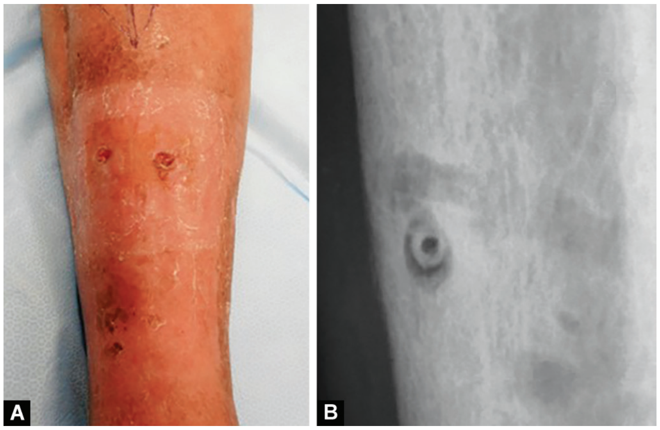
How to cite this article: Frank FA, Pomeroy E, Hotchen AJ, *et al*. Clinical Outcome following Management of Severe Osteomyelitis due to Pin Site Infection. Strategies Trauma Limb Reconstr 2024;19(1):21–25.

Source of support: Nil

Conflict of interest: None

Materials and Methods

In this retrospective single-centre cohort study, we identified 28 patients between 2011 and 2021 who required surgical treatment for Cierny–Mader (C–M) type-III chronic OM after a deep PSI.[19] All patients had skin breakdown with a radiologically proven ring sequestrum (Fig. 1).[20] The 2018 consensus definition for fracture-related infection was used to confirm deep bone infection.[21] We



Figs 1A and B: Preoperative image and X-ray. (A) Sinus on ventral tibia; (B) Ring sequestrum

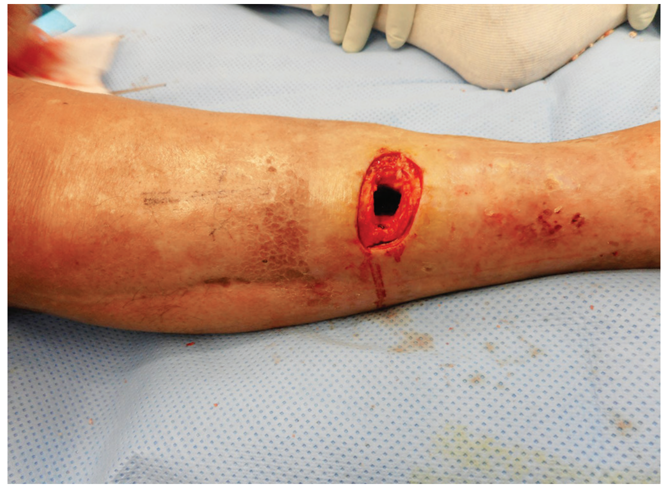


Fig. 2: After resection of sinus and deep debridement OM

Table 1: Checketts–Otterburn classification

Grade	*Characteristics*	*Treatment*
Minor infection		
I	Slight discharge	Improved pin site care
	Redness around pin site	
II	Discharge	Improved pin site care + antibiotics
	Redness of surrounding skin	
	Pain and tenderness of soft tissue	
III	Grade II + no improvement after antibiotics	Affected pin(s) resisted and external fixation continued
Major infection		
IV	Severe soft tissue infection	External fixation must be abandoned
	Several pins involved	
	Pin loosening can be present	
V	Grade IV + radiological changes	External fixation must be abandoned
VI	After initial healing, pin tract	Curettage of pin tract
	Breakdown and discharge	
	Radiological changes	
	(new bone; sequestra)	

Fig. 3: Filling of the defect with local antibiotic carrier

subsequently used the newly published "Practical Definition of Pin Site Infection" to check and confirm that all cases complied with the new definition.[22] The Checketts–Otterburn Classification was used to classify PSIs from grades I–VI (Table 1) and, as all patients had presented with persistent deep infection after pin removal, these were classed as C–O grade VI.[23,24] The severity of the OM was assessed according to C–M (Cierny et al.)[19] and the BACH classification.[25]

The patient demographics, underlying pathology, causative pathogens and intraoperative histology were compared. The outcome of the treatment, including plastic surgery and complications, was recorded.

Surgical Intervention

All interventions were performed utilising the same protocol. This single-stage surgery included the use of a tourniquet if feasible. The skin sinus or ulcer was first excised and five deep tissue samples were taken for microbiological culture and three for histology (Fig. 2).[26–28] Intravenous vancomycin and meropenem were administered empirically after deep sampling.[29,30] After debridement of the sinus track and removal of all dead bone, the resulting cavity was washed with 0.05% aqueous chlorhexidine before being filled with local antibiotic carriers (Fig. 3).

Early in this series, three patients (2011–2012) had defect filling with a synthetic biomaterial of combined calcium sulphate and calcium phosphate which was mixed with vancomycin and gentamicin (Pro-Dense Graft, Stryker, Kalamazoo, USA). One defect was filled with calcium sulphate pellets with tobramycin (Osteoset T, Wright Medical, Arlington, Tennessee) and one with calcium sulphate with gentamicin (Herafill G beads, Heraeus, Hanau, Germany). The subsequent 23 patients had a biphasic ceramic containing calcium sulphate, microcrystalline hydroxyapatite and gentamicin (Cerament G, Bonesupport AB, Lund, Sweden). Of these 23 patients, two had vancomycin added to the mixture. The average amount of Cerament G used was 7.3 mL (range: 1–20 mL). Definitive skin closure was performed either by primary closure or flap coverage (local or free). In all patients in whom there were concerns over the feasibility of primary skin closure, further evaluation was sought from a plastic surgeon in the preoperative clinic and in the theatre. If direct coverage was deemed too precarious or impossible, flap coverage was performed by the plastic surgeon. Postoperatively, culture-specific antibiotics were given after culture results were obtained and continued for 2–12 weeks depending on the advice from the infectious disease specialist.

Outcome Measures

The primary outcome was a recurrence of infection with a follow-up interval of at least 24 months after surgery. Telephone reviews were conducted for all patients who had not completed a 24-month clinical review in person by the start of this study in early 2023. Secondary outcome measures were the need for further surgery, pathological fracture at the site of surgery and prolonged wound drainage after initial treatment.

One patient was lost to follow-up.

Ethical Approval and Statistical Analysis

All patients had given written consent for their data to be used in scientific projects and publications. The study complied with the Declaration of Helsinki and was approved by the hospital governance board as an audit of the outcome. Analysis was performed using descriptive statistics.

Results

Twenty-seven patients were eligible for inclusion. There were 85% male (23/27) patients and the median age was 53.9 years [standard deviation (SD: 10.8)]. The lower limb was predominantly involved (22 tibias and 2 calcanei); only 3 cases involved the upper limb (2 humeri, 1 radius); 18 patients had an external fixation for fractures (67%), while 4 cases of infection occurred after the external fixator was used for deformity correction. Two patients acquired the OM after an ankle fusion with an external fixator. Osteomyelitis was noted to occur at both fine wire and half pin sites and in both monolateral and circular fixator constructs. Three patients were noted to develop an infection around transosseous pins inserted for skeletal traction of fractures. All 27 patients were classed as a Checketts–Otterburn PSI grade VI and with a C–M type-III OM. Fifteen patients were classified as BACH Uncomplicated and 12 were BACH Complex.

Staphylococci were the most common pathogen identified [16 methicillin-sensitive *staphylococcus aureus* (MSSA), 3 methicillin-resistant *staphylococcus aureus* (MRSA) and 2 coagulase-negative *staphylococci* (ConS)]. In four cases, Gram-negative bacteria were cultured. Polymicrobial infections were present in five cases (19%). In four cases no causative pathogen was cultured, but histopathology was in keeping with OM (Table 2).

Table 2: Microorganisms cultured

Staphylococci	21
MSSA	16
MRSA	3
ConS	2
Streptococcus agalactiae	2
Corynebacterium spp.	1
Diphtheroids spp.	1
Gram-negative	4
Achromobacter spp.	2
Pseudomonas aeruginosa	1
Proteus mirabilis	1
Polymicrobial infections	5
Culture negative infections	4

Histopathology was positive for infection in 24 patients. Only one patient had a negative result, whereas one was inconclusive and one case lacked a sample for histology.

In 20 patients, direct primary soft tissue closure was achievable. The other seven patients required flap coverage. All had OM in their lower limb (6 tibias/1 calcaneum). Six cases required a local flap and one case of tibial OM had closure with a free gracilis muscle flap and split skin graft.

The median follow-up was 3.99 years (2.00–8.05 years). After a minimum follow-up of 2 years, all 27 patients were infection free at the site of the former OM.

Twenty-five patients (93%) were treated successfully for infection after their primary surgery alone. Two patients had a recurrence of the infection. One was a patient with a BACH complex infection of the tibia with a culture of MSSA who had excision and direct closure. The second patient had a BACH uncomplicated infection of the radius which also grew MSSA. Treatment was also by excision and direct closure. Recurrence presented at 6 and 78 weeks after initial surgery, respectively. Both recurrences were treated successfully by a repeat of the same protocol.

One patient sustained a fracture through the operated site in the humerus 2 weeks after surgery after twisting the arm while lifting an object. This was treated conservatively and healed without recurrence of infection. Drainage from the surgical wound was observed in 3/27 cases (11.1%). Two of these cases occurred in patients who primarily needed local flap coverage. All three occurred after the application of Cerament G and were treated with dressing changes and continual observation. The drainage resolved spontaneously with no further surgical or medical intervention needed. The average volume of calcium sulphate used in these three cases was 13 mL (range: 3–20 mL) which is almost twice the overall average (7.3 mL).

Discussion

There have been one publication from 1984 and one recent publication on the outcome of treatment of persistent OM after PSI.[17,18] This review included cases with Checketts–Otterburn grade-VI PSI and established corticomedullary OM (C–M type III) only. Previously, the treatment was curettage and antimicrobial therapy.[5,17,23] We report here that thorough debridement with the insertion of local antibiotics, additional systemic therapy and definitive soft tissue coverage was effective in eradicating infection and achieving healing with few complications. This treatment protocol was carried out safely in a single stage.

In comparison to the results of Green and Ripley,[17] curettage alone proved to be insufficient. Both studies have similar distribution patterns of OM, but Green and Ripley were successful in 9 of 14 (64.3%) patients and fared worse in the gram-negative infections (treatment failed in 4 out of 6 cases).[17] The protocol we used involved managing the dead space after debridement with local aminoglycoside antibiotics delivered in a ceramic carrier followed by immediate soft tissue cover. These additions improved the outcome over simple curettage and systemic antibiotics alone.

This approach has been demonstrated to be effective in other forms of OM.[31–33]

Saini et al.[18] published a small series of eight patients who were treated by surgical excision of the affected area following PSI using a novel hydrosurgical device. They reported infection eradication in all 8 patients treated. They also advocated a full excision of the compromised soft tissues and dead bone around the infection. However, this study is not directly comparable to ours. These cases presented soon after fixator removal (mean 46 days) whereas those in our cohort presented over a wide time period, with some at several years after external fixation. Saini et al. reported the ability to close all soft tissue defects primarily after the excision, suggesting that these cases had less severe soft tissue defects. Finally, the minimal follow-up in that group was 7 months (mean: 11.8 months) which is significantly less than ours at a minimum of 2 years (mean: 4 years). This may underestimate the rate of late recurrence.

All patients in our cohort were treated effectively with our single-stage protocol apart from two requiring surgery for recurrence. This can still be viewed as an encouraging result as almost half of the patients (12/27) were classed as “complex” in the BACH classification; this has been shown to be predictive of an adverse outcome.[34] Seven patients required flap coverage for severely compromised soft tissues. In such complex patients, the operation time and length of hospital stay are significantly increased as are the economic implications for the patient and the healthcare system.[35,36]

A limitation of this study is the sample size (27 patients) is small. However, the relevance of taking samples for histopathologic workup is emphasised. In 14.8% of cases, the infection was confirmed through histopathology which is in keeping with the literature on culture-negative infections.[28,37] These four cases might have been missed or poorly treated if not for the additional histologic sampling.

The commonest complication encountered was leakage of fluid from the wound. This is most probably due to the presence of the calcium sulphate in the local antibiotic carrier which dissolves over several weeks and may cause fluid accumulation in the subcutaneous tissues.[38] This problem was treated by observation and regular dressings. Provided the patient remained systemically well, with no new pain at the wound site, this led to complete wound healing without surgery.[33]

The OM following PSIs occurred more often in the lower limbs and most complications were found in the tibia. This is in keeping with the literature that most external fixators are applied to tibias, across (fused) ankle joints or femurs.[9]

Osteomyelitis is a rare complication after PSI and not all patients with external fixators necessarily develop PSI(s). The longer the treatment with an external fixation device or skeletal traction, the higher the likelihood of pin or wire loosening with the development of (deep) PSI and subsequent OM.[39] When OM develops, the implications for the affected limb or patient can be severe. The overall treatment may be compromised and, in severe cases, may need to be abandoned and further surgery with surgical debridement and possible flap coverage is necessary.

The relevance of OM in PSI makes proper pin placement technique even more important. Aside from preventing infection, it is of utmost importance to avoid thermal osteonecrosis which can lead to the formation of a ring sequestrum.[7]

The limitations of this study are that it is a retrospective analysis of a consecutive cohort. Not all patients treated could be included as all attempts to get hold of one patient failed. Moreover, the diagnosis of PSIs still lacks clear definitions and some cases of OM which we treated might have been missed for inclusion in this cohort because we were unaware of a previous relationship to PSI.

As most studies on PSIs focus on prevention or diagnosis, this is an unusual area of research. More data on the optimal treatment strategy is needed but this treatment protocol has proved effective for this group and might serve as a basis for further investigations.

Conclusion

Osteomyelitis after PSI is uncommon but has major implications for the patient. The need for careful pin placement and pin site care to prevent deep infection remains. In the presence of dead bone with established infection, appropriate treatment involves more than surgical curettage. The protocol described here can treat C–M type-III OM successfully, whether in the presence of Gram-negative or multidrug resistant organisms or when treating patients with significant comorbidities.

Clinical Significance

Pin site infection is a very common complication in external fixation. Ensuing OM is rare but the implications for the patient are huge. Careful surgical debridement, insertion of local antibiotics and definitive soft tissue closure can eradicate infection successfully.

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