Original Article

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Role of Antibiotic Cement-coated Nailing in Infected Nonunion of Tibia

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Abstract

Introduction: The infection of long bones along with its nonunion is a chronic and debilitating disorder. It becomes difficult to deal with the situation in which the implant which is used for internal fixation itself becomes a potential media for infection because of the formation of biofilms and adhesions. Traditionally, this situation is managed by a two-stage procedure for controlling the infection first and then treating the nonunion. This study has been undertaken to explore antibiotic cement-coated nailing as a single stage treatment modality for achieving stability and treating of the infection at the same time.

Materials and Methods: 20 patients (above 18years of age) with nonunion of tibia associated with infection with bone gap <2 cm were managed using antibiotic cement-coated Kuntscher nail. Antibiotics used were a combination of vancomycin and teicoplanin.

Results: Infection was controlled in 95% of the patients. Bony union was achieved in 12 of 20 (60%) patients with antibiotic cement nailing as the only procedure with average time of union of 32 weeks. Bone grafting or exchange nailing type additional procedures were required in the remaining eight patients, and this was done in six patients, with union of the fracture. Two patients refused to undergo further procedures. The various complications encountered during this study were difficult nail removal in three cases, broken nail in two cases, and bent nail in 1 case. Recurrence of infection was observed in two patients. The average period of follow-up was 12 months.

Conclusion: Antibiotic cement impregnated nailing is a simple, economical, and effective single-stage procedure for the management of infected nonunion of the tibia. It has many advantages over external fixators, as it eliminates the complications and has good patient compliance. The method utilizes existing easily available instrumentation and is technically demanding and therefore can be performed at any hospital.

Keywords: Nonunion, infected, antibiotic, cement, nailing.

Introduction

Even today,in terms of cost and time effective treatment, the surgeon faces a very complex contribute to infected nonunions, which include open fractures, loss of soft tissue or bone, chronic osteomyelitis with pathologic fractures, infection after internal fixation, and debridement of infected bone [1]. When there is biofilm formation or bacterial adhesion on the implant used for internal fixation, it becomes even difficult to deal with the situation [2].Biofilm-forming bacteria are responsible for most of the orthopedic trauma infections[3]. Biofilm consists of hydrated matrix of polysaccharide and protein. Once formed, it protects the microorganisms from antimicrobials, opsonization, and phagocytosis, thus contributing to the chronicity of infections [4]. Ciemy and Mader formulated four principles to cure biofilm-related infections; they are (1) complete surgical debridement with dead space management, (2) fracture/nonunion stabilization, (3)soft tissue coverage, and (4)adequate antibiotic levels [5]. Traditionally, treatment of an infected nonunion follows a two-stage procedure. Debridement with or without antibiotics to convert an infected nonunion to aseptic nonunion is the first step in this two-step treatment protocol. The second stage is performed to achieve stability by either external or internal fixation with or without bone grafting[2,6, 7, 8, 9, 10].The use of an antibiotic-impregnated cement-coated IM nailing for infected nonunion of tibia and femur fractures has been well documented in literature[11, 12, 13, 14, 15, 16, 17, 18]. Unlike cement beads, the cement nail provides stability across the fracture site. Osseous stability is an important factor in the management of an infected nonunion[17,18]. Antibiotic cement allows higher concentration of antibiotic at the local site that is achievable with systemic antibiotics and is associated with fewer complications and side effects. Antibiotic cement has a therapeutic effect on refractory infection as it has been shown to elute antibiotic at the local site for upto 36 weeks[16,17]. Hence, by providing stability and treating infections at the same time along with other advantages such as early mobilization, avoidance of pin site infections, ease of performance, and being cost-effective antibiotic cement-coated

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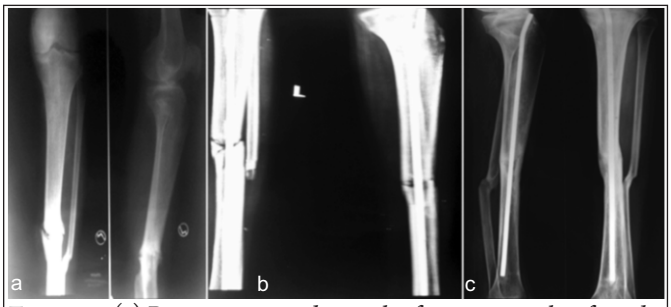

Figure 1: (a) Pre-operative radiograph of a patient with infected nonunion of tibia, (b) post-operative radiograph after debridement and antibiotic cement-coated nailing, and (c) radiograph showing bony union achieved at 28 weeks.

Figure 2: (a) Broken nail, (b) bent nail, and (c) nail migration into the ankle joint.

nailing acts as a single-stage procedure unlike traditional methods of the management of infected nonunion. Broad spectrum of activity, heat stability, and low allergenicity are some of the properties that should be present in the antibiotics used for this purpose. Gentamicin has been the most widely used agent followed by vancomycin[19,20]. In our study, we used the combination of vancomycin and teicoplanin as both these antibiotics have the desired properties. The purpose of our study was to evaluate the outcome of antibiotic cement-coatednailing in the management of infected nonunion of the tibia in terms of infection control and bony union.

Materials and Methods

The following study is a prospective study. The total number of patients included in this study was 20 (19 males, 1 female) with infected nonunion of tibia aged from 22 to 61 years (mean,39 years) who were treated using antibiotic cement-coated nailing. Patients with diaphyseal fractures of tibia with bone gap <2 cm were included in this study. The patients excluded were the ones who were allergic to vancomycin or teicoplanin. Of these 20 patients, 13 sustained open fractures and 17 had undergone one or multiple procedures. 12 patients had positive pre-operative cultures for Staphylococcus aureus of which 10 were resistant to gentamicin. Eight patients had cultures that were negative despite clinical evidence of infection. Informed consent was taken for surgery after thorough pre-operative evaluation. Removal of the implant was the first step in cases previously operated. This was followed by thorough debridement of the infected bone and soft tissues with copious lavage. The specimens obtained intraoperatively were sent for culture and sensitivity. The next step involved the reaming of an intramedullary canal and preparing it to fit a larger diameter nail, which was followed by thorough was with saline. This was followed by changing of gowns and gloves by the surgical team. The limb was prepared again and redraped. An appropriate size antibiotic-impregnated nail was prepared on a separate sterile table. The required length of the nail was determined. Kuntscher nail (K-nail) of 6 or 7 mm diameter was chosen and coated with bone cement up to 1mm less than the diameter of the last reamer used. A mixture was prepared which involved 40 g of cement thoroughly mixed with 2 g vancomycin and 2g teicoplanin, following which the polymer was added. Anendotracheal tube of the internal diameter same as the desired diameter of the cement-coated nail was then filled with the doughy mixture of antibiotics and cement. K-nail of diameter 2 mm less was then pushed through this endotracheal tube and allowed to set for 10-15 min. The next step involved cutting of the endotracheal tube using a surgical knife to retrieve the K-nail uniformly coated with the antibiotic cement. This was followed by antegrade insertion of the antibiotic-coated nail in the tibia. Debonding of the nail-cement during insertion was avoided by allowing adequate time for the cement to set and bond with the nail. Postoperatively, the wound was inspected at 48-72 hrs intervals, and the patient was administered intravenous antibiotics as per culture and sensitivity reports for 2-4weeks. After this, the patient was discharged on oral antibiotics for a time period depending on individual patient characteristics, wound condition, and the involved organism. No sooner did the wound heal, a patellar tendon-bearing cast or brace was applied, and gradual weight-bearing was started. Active physiotherapy for regaining ankle and knee mobility was instituted till the range of movement was satisfactory. Patients were followed up once a month for 3 months, and then, once every 2-3 months till the final follow-up. The average period of follow-up was 12 months. Evaluation of the patients in follow-up was done in terms of infection control and bony union. They were divided into following categories (1) infection controlled, sound bony union, (2) infection controlled, signs of fracture healing with partial union, (3) infection controlled, no signs of fracture healing, and (4)infection persisting, no signs of fracture healing. Depending on which category the patient was included in follow-up, it was decided who needed further intervention like bone grafting or exchange nailing.

Table 1: Control of infection

	Number of cases (%)
Infection controlled	19 (95)
Infection not controlled	01 (05)

Table 2: Bony union

	Number of cases (%)
Union without additional procedure	12 (60)
Union with additional procedure	06 (30)
No union	02 (10)

Table 3: Additional procedures

Procedure	Number of patients
Bone grafting	3
Exchange interlocking nail with bone grafting	3
Refused	2

Results

After an average follow-up of 12 months, infection was found to be controlled in 19 of 20 patients (95%) (Table 1). 18 out of 20 patients achieved bone union with or without additional procedures (Table

2). Eight patients required additional procedures to treat infection or achieve bone union. Bone union after additional procedures was achieved in 6 out of 8 patients (Table 3). One patient with persisting infection and one patient with controlled infection refused to undergo further evaluation. One patient who presented with bent antibiotic cement nail in situ with infection still persisting underwent exchange nailing with a new antibiotic cement nail and went on to achieve bone union with no additional procedure. Hence, in 12 of 20 patients (60%), antibiotic cement nailing was the only procedure required to achieve infection control and bone union. 3 weeks were the average time taken for union, minimum being 24 weeks and maximum being 44 weeks. Average time taken for union in patients in whom antibiotic cement nailing was the only procedure required was about 32 weeks (Fig.1a,b,c). Difficult nail removal in three patients, nail breakage in two patients (Fig.2a), nail bending in one patient (Fig. 2b), and nail migrating into the ankle joint (Fig. 2c) in one patient were some of the complications that we came across in our study. Two cases also presented with recurrence of infection.

Discussion

The treatment of infected nonunion requires procedures to control the infection and to provide stability to achieve union[14]. There is no single method of treatment available for the management of infected nonunion. Infected nonunion has been managed using a two-step procedure to control the infection first and then to treat the nonunion. To control the infection, it is necessary that the antibiotics be delivered to the infection site systemically or locally. Excessive fibrosis may occur around the nonunion site if there is the presence of long-term infection and excessive debridement, which may hinder the antibiotic permeability[21]. Hence, local site administration of antibiotic is far more beneficial than systemic administration of antibiotics. The use of antibiotic-impregnated polymethylmethacrylate cement beads for local delivery of antibiotics without any systemic toxicity has been well documented for the management of osteomyelitis and open fractures[22,23]. However, the disadvantage of these antibiotic-coated cement beads includes the inability to provide any stability across the fracture site and also they cannot be placed in the intramedullary canal as it entails difficult removal due to fibrous in growths. The antibiotics thus used must have broad spectrum of activity, should be heat stable and have good elusion properties from the cement and should have low allergenicity. A combination of vancomycin with gentamicin or tobramycin was used by most researchers in the past [11,14,19,20,21]. In our study, we used a combination of vancomycin and teicoplanin as most of the culture and sensitivity reports from the patients were reporting Staphylococcus aureus which was resistant to gentamicin. Increasing numbers of gentamicin-resistant species are being reported to cause deep infections, including medullary infections [24,25]. The uniqueness of our study is that no other researcher in the past has used teicoplanin, even though the stability and biocompatibility of this antibiotic in bone cement are well established[26,27]. The spectrum of activity is widened by the simultaneous use of two antibiotics. Stability across the fracture site can be achieved by external or internal fixation. However, external fixators have been associated with high prevalence of pin site infections, muscle contractures, and joint stiffness[27,28].When internally fixed the implants used for internal fixation act as a foreign body and can be a potential media for infection with the formation of biofilms. The presence of foreign body and biofilm makes the eradication of infection more difficult by systemic antibiotics. A high concentration of antibiotic is delivered at the local site through antibiotic cement impregnated nails without causing any systemic toxicity along with providing stability at the nonunion site, thereby converting a two-stage procedure of treating nonunion into a single-stage procedure. The various complications such as pin site infections, joint stiffness, and muscle contractures are avoided by antibiotic cement nails as the patient can be mobilize dearly. In following, the initial report by Paley and Herzenberg in 2002 [11], many researchers have produced good results using this procedure for the treatment of infected nonunion. Paley and Herzenberg studied a small sample of nine cases and reported infection control in all the cases. Thonse and Conway in 2007 published a study with a large sample size of 52 patients and reported infection control in 85% of the patients [14]. Qiang et al. reported infection controlled in 17 of 18 (94.4%) cases12. In our study, infection was completely eradicated in 95% of the cases. Similar results suggest that antibiotic cement impregnated nailing is definitely a good means to eradicate the infection. In terms of bony union, the results vary in different studies. Thonse and Conway reported bony union in 73% of the cases with antibiotic nail as the index procedure. Qiang et al. reported it as index procedure in about 22% cases, the same being 60% in our study. Thonse and Conway had used interlock nails for the preparation of antibiotic cement rods. Shyam et al.[30] published a study in which 22 of 25 patients required a secondary procedure. They had divided the patients into three groups according to the bone gap and reported that infection control and union rate were both poor in patients with increasing bone gap. In a follow up paper the same group of authors concluded that in bone gap less than 4 cms antibiotic cement impregnated nailing can achieve both infection control and union [31]. In our study, two patients reported with broken nail and one patient with bent nail which was due to noncompliance and early unprotected weight-bearing. Another complication observed in our study was difficult nail removal, seen in three patients, which may be attributed to improper nail preparation and late presentation to hospital for removal. The nail may get incarcerated inside the medullary canal due to fibrous growths and cement nail bonding. Recurrence of infections occurred in two patients in our study. It was also reported by a few other researchers such as Qiang et al.[12] and Selhi et al.[32]. Timely removal of nail is recommended once the infection has subsided because theoretically live bacteria are known to persist on antibiotic-impregnated cement under in vitro conditions [33].

Conclusion

Antibiotic cement impregnated nailing is a simple, economical, and effective single-stage procedure for the management of infected nonunion of tibia. It has advantages over the more traditional form of treatment-like external fixator in that it eliminates the complications associated with external fixators and has good patient compliance. The method utilizes existing easily available instrumentation and materials and is technically less demanding, and therefore can be performed at any general orthopedic center.

References

1. Toh CL, Jupiter JB. The infected nonunion of the tibia. ClinOrthopRelat Res 1995;315:176-191.
2. Patzakis MJ, Zalavras CG. Chronic posttraumatic osteomyelitis and infected nonunion of the tibia: Current management concepts. J Am AcadOrthopSurg 2005;13(6):417-427.
3. Stoodley P, Ehrlich GD, Sedghizadeh PP, Stoodley LH, Baratz ME, Altman DT, et al. Orthopaedic biofilm infections. CurrOrthopPract2011;22(6):558-563.
4. Nelson CL. The current status of material used for depot delivery of drugs. ClinOrthopRelat Res 2004;427:72-78.
5. Cierny G, Mader J. The surgical treatment of adult osteomyelitis. In: CMC Evarts, editor. Surgery of the Musculoskeletal System. New York, USA: Churchill Livingstone; 1983. p. 4814-4834.
6. Court-Brown CM. Fractures of the tibia and fibula. In: Bucholz RW, Heckman JD, Court-Brown CM, editors. Rockwood and Green's Fractures in Adults. 6th ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2006. p. 2080-2146.
7. Beals RK, Bryant RE. The treatment of chronic open osteomyelitis of the tibia in adults. ClinOrthopRelat Res 2005;433:212-217.
8. Ueng SW, Chuang DC, Cheng SL, Shih CH. Management of large infected tibial defects with radical debridement and staged double-rib composite free transfer. J Trauma 1996;40(3):345-350.
9. Chen CE, Ko JY, Wang JW, Wang CJ. Infection after intramedullary nailing of the femur. J Trauma 2003;55(2):338-344.
10. Wu CC, Shih CH. Distal tibial nonunion treated by intramedullary reaming with external immobilization. J Orthop Trauma 1996;10(1):45-49.
11. Paley D, Herzenberg JE. Intramedullary infections treated with antibiotic cement rods: Preliminary results in nine cases. J Orthop Trauma 2002;16(10):723-729.
12. Qiang Z, Jun PZ, Jie XJ, Hang L, Bing LJ, Cai LF. Use of antibiotic cement rod to treat intramedullary infection after nailing: Preliminary study in 19 patients. Arch Orthop Trauma Surg 2007;127(10):945-951.
13. Madanagopal SG, Seligson D, Roberts CS. The antibiotic cement nail for infection after tibial nailing. Orthopedics 2004;27(7):709-712.
14. Thonse R, Conway J. Antibiotic cement-coated interlocking nail for the treatment of infected nonunions and segmental bone defects. J Orthop Trauma 2007;21(4):258-268.
15. Sancineto CF, Barla JD. Treatment of long bone osteomyelitis with a mechanically stable intramedullar antibiotic dispenser: Nineteen consecutive cases with a minimum of 12 months follow-up. J Trauma 2008;65(6):1416-1420.
16. Nelson CL, Hickmon SG, Harrison BH. Elution characteristics of gentamicin-PMMA beads after implantation in humans. Orthopedics 1994;17(5):415-416.
17. Nizegorodcew T, Palmieri G, Marzetti E. Antibiotic-coated nails in orthopedic and trauma surgery: State of the art. Int J ImmunopatholPharmacol 2011;24 1 Suppl 2:125-128.
18. Riel RU, Gladden PB. A simple method for fashioning an antibiotic cement-coated interlocking intramedullary nail. Am J Orthop (Belle Mead NJ) 2010;39(1):18-21.
19. Dhanasekhar R, Jacob P, Francis J. Antibiotic cement impregnated nailing in the management of infected nonunion of femur and tibia. Kerala J Orthop2013;26(2):93-97.
20. Kim JW, Cuellar DO, Hao J, Seligson D, Mauffrey C. Custom-made antibiotic cement nails: A comparative study of different fabrication techniques. Injury 2014;45(8):1179-1184.
21. Akinyoola AL, Adegbehingbe OO, Aboderin AO. Therapeutic decision in chronic osteomyelitis: Sinus track culture versus intraoperative bone culture. Arch Orthop Trauma Surg 2009;129(4):449-453.
22. Beals RK, Bryant RE. The treatment of chronic open osteomyelitis of the tibia in adults. ClinOrthopRelat Res 2005;433:212-217.
23. Henry SL, Ostermann PA, Seligson D. The prophylactic use of antibiotic impregnated beads in open fractures. J Trauma 1990;30(10):1231-1238.
24. Chen CE, Ko JY, Wang JW, Wang CJ. Infection after intramedullary nailing of the femur. J Trauma 2003;55(2):338-344.
25. Tunney MM, Ramage G, Patrick S, Nixon JR, Murphy PG, Gorman SP. Antimicrobial susceptibility of bacteria isolated from orthopedic implants following revision hip surgery. Antimicrob Agents Chemother 1998;42(11):3002-3005.
26. Chang Y, Chen WC, Hsieh PH, Chen DW, Lee MS, Shih HN, et al.In vitro activities of daptomycin-vancomycin-and teicoplanin-loaded polymethylmethacrylate against methicillin-susceptible, methicillin-resistant, and vancomycin-intermediate strains of Staphylococcus aureus. Antimicrob Agents Chemother 2011;55(12):5480-5484.
27. Öztemür Z, Sümer Z, Tunç T, Pazarcé Ö, Bulut O. The effect of low dose teicoplanin-loaded acrylic bone cement on biocompatibility of bone cement. ActaMicrobiolImmunol Hung 2013;60(2):117-125.
28. Green SA. Complications of external skeletal fixation. ClinOrthopRelat Res 1983;180:109-116.
29. Paley D. Problems, obstacles, and complications of limb lengthening by the Ilizarov technique. ClinOrthopRelat Res 1990;250:81-104.
30. Shyam AK, Sancheti PK, Patel SK, Rocha S, Pradhan C, Patil A. Use of antibiotic cement-impregnated intramedullary nail in treatment of infected non-union of long bones. Indian J Orthop 2009;43(4):396-402.
31. Pradhan C, Patil A, Puram C, Attarde D, Sancheti P, Shyam A. Can antibiotic impregnated cement nail achieve both infection control and bony union in infected diaphyseal femoral non-unions? Injury. 2017 Aug;48 Suppl 2:S66-S71
32. Selhi HS, Mahindra P, Yamin M, Jain D, De Long WG Jr, Singh J. Outcome in patients with an infected nonunion of the long bones treated with a reinforced antibiotic bone cement rod. J Orthop Trauma 2012;26(3):184-188.
33. Kendall RW, Duncan CP, Smith JA, Ngui-Yen JH. Persistence of bacteria on antibiotic loaded acrylic depots. A reason for caution. ClinOrthopRelat Res 1996;329:273-280.

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