

Antibiotic-Impregnated Cement Coated Ilizarov Rod for Infected Non-Union of Femur

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ABSTRACT

Objective: To determine the effectiveness of antibiotic-impregnated cement coated Ilizarov rod for infected non-union of the femur.

Methodology: It was a prospective observational study conducted at the Department of Orthopedic Surgery Services Hospital, Lahore from December 2018 to December 2020. After approval from the Hospital Ethical Review Board, the study was conducted on 50 patients with infected non-union of the femur or established osteomyelitis of the femur after intramedullary (IM) nailing. Each patient underwent an X-ray of the shaft of the femur with hip and knee joint, both anterior-posterior (AP) & lateral views, complete blood count (CBC) with erythrocyte sedimentation rate (ESR), and C-reactive protein (CRP) as baseline investigations. The intramedullary nail was removed and irrigation with resident assessment instrument (RAI) system was done with 7-8 liters of normal saline. An Ilizarov rod of size 5 mm width and length equal to that of IM nail already introduced, was used. It was impregnated with bone cement coated with 2 g of vancomycin and 2 g of gentamicin.

Results: A total of 50 patients were enrolled in our study with a mean age of 48.32 ± 12.59 years and a range between 40-70 years. Thirty eight (76%) were males and 12(24%) were females. In the initial culture, the *Staphylococcus aureus* was isolated in 30(60%) patients; *Escherichia coli* (*E. coli*) was present in 8(16%) patients, *Pseudomonas species* in 4(8%) patients, mixed infection in 4(8%), while in 4(8%) patients culture was negative. Vancomycin and gentamicin 2 g each were used with bone cement to impregnate the Ilizarov rods in all the cases. Thirty eight (76%) patients had discharging sinus at the time of presentation. In all these 38 patients, CRP & CBC with ESR returned to normal after 4 to 6 months. Thirty eight out of 50 patients showed signs of union radiologically after 5-6 months.

Conclusion: Antibiotic-impregnated cement rods are very effective in the treatment of infected non-union of the femur. It is a unique implant to control the infected non-union and provides stability for fracture union.

Keywords: Femoral fractures. Bone cement. Intramedullary nailing. Antibiotics.

INTRODUCTION

Road traffic accidents (RTAs) are one of the most leading causes of bone fractures. As a result of an increase in the number of road traffic collisions, long bone fractures are common resulting in significant damage to soft tissue and bone, exposing the patient to risk of infection. The most common fracture encountered after RTA is that of femur bone.¹ Infections as a result of fractures can be highly debilitating and can cause complications which may ultimately lead to permanent functional loss or amputation.²

Intramedullary nailing is considered as the gold standard for the fracture of the shaft of the femur. Intramedullary nailing can be closed or open due to its biological and mechanical behavior. Delayed or inadequate treatment of infection allows the bacteria to spread resulting in diffuse infection. Systemic antibiotics cannot reach the interface of the implant because of the biofilm formed by bacteria.³ After debridement, bacterial residues may remain in the

medullary canal or in the surrounding tissue resulting in the formation of biofilm which matures after 72 hours. The antibiotic resistance is further aggravated by osteonecrosis and poor blood supply. Various factors like bone loss, soft tissue loss, open fractures, and chronic osteomyelitis are reasonable for infected non-union. The benefits of antibiotics loaded materials are high local antibiotics concentration and elution, accurate positioning, low side effects, bone regeneration, and infection eradication because of the local antibiotics delivery system in loading doses.⁴ The most common bacteria isolated from the infected fracture site culture is *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Escherichia coli*, and in rare cases there is mixed infection. Depending upon the progress of fracture union, the existing status of the bone, and the extent of infection, different treatment strategies are available.⁵

Infection is classified into 3 stages. Stage 1 is bacterial cellulitis and it occurs after 2-6 weeks. There is no need for wound exploration and surgical debridement in this stage. It usually resolves with a high dose of intravenous (IV) antibiotics. The second stage occurs 2-9 months after the surgery. There is wound discharge or wound necrosis with delayed wound healing at the operative site. If the implant is providing stability, there is no need for its removal. If it is unstable and bone infection is present, implant removal, wound debridement, stabilization of the fracture, and IV antibiotics for suppression of infection are required

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until the union is achieved. These infections can be treated successfully with antibiotic nails. In 3rd stage, established osteomyelitis in the medullary canal occurs after 9 months of initial treatment. In this stage, thorough wound debridement, removal of all dead and devitalized tissue with stabilization of fracture, and restoration of bone loss is required. In these patients, the implant is removed and Ilizarov is applied to stabilize the fracture especially when large bone defects are present.⁶

Infected non-unions are difficult to treat, antibiotic cement-coated rods have been shown to provide stability in non-union of bones. Antibiotic-impregnated polymethylmethacrylate (PMMA) nails provide local antibiotics, exhibit excellent osteogenesis, and have drug loading properties. These nails provide accurate positioning with less side effects and a longer duration of treatment.⁷

The antibiotics-impregnated PMMA rods can also be made from Ilizarov threaded rods, Ilizarov pins, intramedullary guide wires of 3 mm diameter, ball-tipped guide wires, Steinmann pins, Kuntscher nail (K-nail), and Kirschner wires (K-wires).⁸ Antibiotic nails can be impregnated either with PMMA or calcium sulphate. Nails can also be coated with antibiotics and growth factors. The antibiotics usually used are vancomycin 2 grams and gentamicin 2 grams. The size of cement coated rod should be less than 1 mm than the last reamer used for reaming.⁹

It is difficult to treat infected non-union of bone fractures. So, the present study was conducted to find out the effectiveness of antibiotics impregnated cement coated Ilizarov rod for infected non-union of the femur. It will help surgeons in treatment of infected non-union of the femur.

METHODOLOGY

It was a prospective observational study conducted at the Department of Orthopedic Surgery Services

Hospital, Lahore from December 2018 to December 2020. After approval from the Hospital Ethical Review Board, the study was conducted on 50 patients with infected non-union of the femur or established osteomyelitis of the femur after intramedullary (IM) nailing. All patients presented with infected non-union of the femur, 4-7 months after the surgery and h clinical and radiological evidence of sepsis and infected non-union were included by consecutive sampling technique. A detailed history including comorbidities, number of surgical procedures to treat the infection, previous culture & sensitivity reports, antibiotics treatment, and previous hospital admission were taken from each patient under the study and noted on a proforma.

Written informed consent was taken from all the patients. Before the procedure, each patient underwent an x-ray of the shaft of the femur with hip and knee Joint, both AP & lateral views, CBC with ESR, and CRP as baseline investigations. The IM nail was removed, irrigation with the RAI system was done with 7-8 liters of normal saline. The medullary canal was reamed. The reamer head size used was decided preoperatively after information from the size of the implant already used for the initial surgical procedure. The size of the reamer head was 1 mm wide than the diameter of the antibiotic nail used (Figure 1). All sinuses and infected soft tissue were excised. Ilizarov rod of size 5 mm width and length equal to that of IM nail already introduced was used. It was impregnated with bone cement having high viscosity with 2 gram of vancomycin and 2 gram of gentamicin. All reaming material and necrotic material were sent for a culture sensitivity test. All patients under the study were given IV antibiotics according to the culture sensitivity report.

Serial biochemical analysis i.e. CBC with ESR and CRP were conducted to judge bone infection. X-rays were used to monitor the treatment efficacy i.e., radiological reunion at 6 weeks, 12 weeks & 6 months.

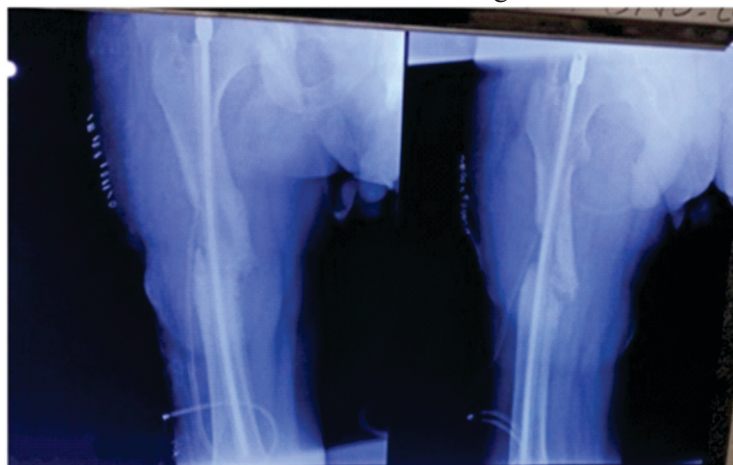


Figure 1: Antibiotic-Impregnated Nail of Study Participant

STATISTICAL ANALYSIS

Data was analyzed using Statistical Package for the Social Sciences (SPSS) version 25. Mean±SD was calculated for age and frequency & percentage for the quantitative variables such as gender, organism isolate, and radiological reunion.

RESULTS

Fifty patients were enrolled in our study with a mean age of 48.32±12.59 years and age range between 40-70 years. Out of 50 patients, 38(76%) were males and 12(24%) were females. All these patients were having stage 2 infection and were infected 4-7 months after the surgery. In the initial culture *Staphylococcus aureus* was isolated in 30(60%) patients, *E. coli* was present in

8(16%) patients, *Pseudomonas species* in 4(8%) patients, mixed infection in 4(8%) patients, and culture was negative in 4(8%) patients. Vancomycin 2 gram and gentamicin 2 gram were used with bone cement to impregnate the Ilizarov rods in all the cases. Thirty eight patients had discharging sinuses at the time of presentation. In all these 38(76%) patients CRP & CBC with ESR returned to normal after 4 to 6 months. Thirty eight (76%) patients showed signs of union radiologically after 5-6 months. In the remaining 12 patients CBC, ESR & CRP returned to normal after 7 months but did not show any sign of union. In these 12 patients, the cement-antibiotic coated nail was removed and they underwent revised IM nailing after the removal of Ilizarov rods (Table 1).

Table 1: Study Variables of Patients Included in the Study

Study Variables (n=50)		Frequency and Percentage
Age (Years)	Mean±SD	48.32±12.59
	40-55	38(76%)
	56-70	12(24%)
Gender	Male	38(76%)
	Female	12(24%)
Organism Isolate After Culture	<i>Staphylococcus aureus</i>	30(60%)
	<i>E. Coli</i>	8(16%)
	<i>Pseudomonas species</i>	4(8%)
	Mixed Infection	4(8%)
	No Isolate	4(8%)
Radiological Reunion After 6 Months	Yes	38(76%)
	No	12(24%)

DISCUSSION

Fractures of the femur are a very common complication post RTAs which mostly lead to infected non-union of the femur. These can be difficult to treat with a high risk of reinfection and persistence of non-union.¹⁰ Standard protocols on custom-made implants coating strategies are scarce and available studies are limited. Some studies use antibiotics containing cement rods as a staged procedure while others use it as a simultaneous control of infection for achieving fracture union.¹¹

The most common bacteria isolated in our study was *Staphylococcus aureus*. A study by Rupp et al., also reported the most common organism in infected non-unions being *Staphylococcus aureus*.¹²

In our study, vancomycin and gentamicin were used as antibiotics with bone cement. These are heat stable, broad spectrum, and are hypoallergenic. These also have no deleterious effects on bone healing and are good choices regarding their elution properties from

bone cement.¹³ A study by Shukla et al., also used vancomycin, gentamicin along with tobramycin and cefazolin as antibiotics of choice.¹⁴

In this study, we used antibiotic-impregnated bone cement Ilizarov rods. It provided not only stability but also eradicated the infection. We achieved the union in 38 patients with this nail, while 12 patients had non-union. In twelve patients, the implant was removed and intramedullary interlocking nailing was done. Another study was conducted to observe the role of antibiotic cement-coated nailing in infected non-union fracture. It was concluded that antibiotic-coated nail has an advantage over external fixators and provides better patient compliance.¹⁵ Another study was conducted to evaluate the role of antibiotic-impregnated rod in infected non-union of long bones. The study reported that this treatment modality cured infection in all 7(100%) patients and union was achieved in 5(71%) cases.¹⁶ A study conducted in India pointed out that

antibiotic-impregnated nailing is a highly productive method in terms of finances and simplicity for the treatment of infected non-union of long bones.¹⁷

Koury et al. concluded that antibiotic-impregnated nails provide a useful & simple procedure for the treatment of bone sepsis. These techniques provide simultaneous stability, union, and control of infection. The use of threaded core provides a successful cement hold.³ Another study was conducted on 21 patients with infected non-union fracture. They concluded that in infected non-union, both infection control and osseous union can be achieved in a significant number of patients with antibiotic-impregnated cement nails.¹⁸ In 2019 Chavn et al. used antibiotic coated nails for patients with infected non-union fracture of the femur. They concluded that infection was controlled in 90% of the cases, while the union was achieved in 66% of the patients.⁴ Pruthi et al. conducted a study on antibiotic-coated nails in infected non-union of long bones and they came to the conclusion that antibiotic coated nails not only provided mechanical stability but also delivered a high concentration of antibiotics for the control of infection.¹⁹

The management of postsurgical osteomyelitis and infected non-union involves a lot of factors and has several components.²⁰ The components include removal of the infected implant, thorough debridement of all devitalized tissue and bone, dead space management with local delivery of antibiotics for the control of infection, soft tissue coverage, and bone reconstruction.^{7,21} Dar et al. conducted a study on antibiotic-impregnated cement-coated Ilizarov rods for the treatment of infected non-union of long bones. They showed that the implant is very effective in controlling the infection as well as fracture union, simultaneously.²² In 2018, Cho et al. demonstrated that antibiotic-coated cement threaded hinged rod can be used as an effective intramedullary spacer and serves as a local source of antibiotic delivery, offers bone stability, and makes implant removal easier.⁸ Antibiotic-coated nail is a simple, economical, less demanding, and effective procedure for treating the infection.²⁰ Patient compliance is good and it avoids the complication of an external fixator. Antibiotics used for nail coating should be broad-spectrum, hypoallergenic, and heat-stable.⁹

CONCLUSION

Antibiotic-impregnated cement rod is very effective in the treatment of infected non-union of the femur. It is a unique implant to control the infected non-union and provides stability for fracture union.

LIMITATIONS & RECOMMENDATIONS

The outcomes in our study were not compared with other surgical strategies for the management of infected

non-union. Although good results were achieved with this mode of treatment, still additional prospective studies with a large number of cases are recommended to confirm our findings.

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