Functional Outcome of Antibiotic Impregnated Nail in Infected Non-Union of Tibia and Femur - A Prospective Observational Study, Trichur, Kerala

Arjun Dev Naroth Palakandy[1], Manoj Murungodiyil Kunjappan[2], Jose Francis[3]

[1, 2, 3] Department of Orthopaedics, Government Medical College, Trichur, Kerala, India.

ABSTRACT

BACKGROUND

Infected non-union is a complex, debilitating and challenging disorder affecting orthopaedic surgeon and patient in terms of cost and time.[1] Antibiotic impregnated nail has been a cheap and effective method used for treatment of infected non-union. Factors that may lead to infected non-union are many.[2,3] High local concentrations of antibiotics with minimal systemic levels and without systemic side effects make local antibiotic therapy a very useful technique in treating infected non-union.[4] Buchholz and Engelbrecht were the first to use antibiotic impregnated cement.[5] Major advantage of using antibiotic impregnated cement is, it provides high concentration of antibiotics locally with less systemic side effects.[6] The purpose of this study was to determine the functional outcome of antibiotic impregnated nail in treatment of infected non-union of femur and tibia. Antibiotic cement impregnated intra-medullary nail can provide stability, help in control of infection,[7] is easy to remove, and also provides all the advantages of the cement beads.[8,9]

METHODS

This prospective study was done on 25 cases at Government Medical College Thrissur from 01 September 2016 to 01 April 2018**.** Functional results were evaluated with regard to control of infection, bony union, deformity, limb leg discrepancy and complications (both intra and post-operative complications).

RESULTS

Most of the cases had type 2 open injury initially, accounting for 49 %. *Staphylococcus aureus* was reported in 56 % of cases. Infection control was achieved in 23 cases. Bony union was visualised in 18 cases, remaining 5 cases united following bone grafting. In 2 cases there was no control of infection and no bony union was achieved, later antibiotic nail removal and Ilizarov fixation was planned. Bone grafting was done in 10 cases.

CONCLUSIONS

Antibiotic impregnated cement nailing is a simple, economical and very effective procedure with less complication and shorter duration of treatment when compared with other conventional procedures.

KEYWORDS

Infected Non-Union, Long Bones, Antibiotic Impregnated Cement Nail

Corresponding Author:
Dr. Manoj Murungodiyil Kunjappan,
Associate Professor,
Department of Orthopaedics,
Q. No IV/2, Government Medical College,
Trichur – 680596, Kerala, India.
E-mail: drmanojmk@hotmail.com

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BACKGROUND

In an era of high velocity injuries, compound fractures are very common in orthopaedic practice and despite of preventive measures taken pre-operatively and post operatively, infected non-unions are still common and they pose real challenge to the treating surgeon and make the patient debilitating.

Infected non-union is one of the most challenging problem for the orthopaedic surgeon and at the same time make patient debilitated.[1] With considerable morbidity and healthcare costs, despite advances in antibiotics and orthopaedic surgical techniques, infected non-union remains difficult to address and tackle. The persistence of the infection is mainly contributed with the presence of poorly vascularized tissues, the adherence of bacteria to the bone and implants and slow bacterial replication rate. Associated factors that may lead to infected non-union are compound wound, loss of soft tissue or bone, severe comminution, gross displacement, improper and insufficient immobilization of fracture, a large bone defect, exposed bone devoid of vascularised tissue, diabetes, chronic osteomyelitis.[2,3]

Non-union in the presence of infection presents with the dual problem of controlling infection and providing stability. Local antibiotic therapy is a useful technique that results in high local concentrations of antibiotics with minimal systemic levels and without systemic side effects.[4]

We present our single-procedure technique of treatment with a nail that is coated with antibiotic-impregnated bone cement, which combines delivery of antibiotics locally as well as maintaining good alignment and stability following internal fixation. This provides stability as well as helps in control of infection.[7]

Antibiotic-impregnated cement was first used by Buchholz and Engelbrecht.[5] It provides high concentration of antibiotics locally with less systemic side effects.[6] Gentamicin has been the most widely used agent initially followed by vancomycin. The spectrum of activity and elution properties are widened and enhanced with the combined use of gentamicin and vancomycin with bone cement. Now a days, Vancomycin is most widely used antibiotic because of its broad spectrum activity, heat stability and low allergenicity. Use of antibiotic cement beads in cases of osteomyelitis was first noted by Klemm. Cement beads fill the dead space, and also provide high concentration of antibiotics locally.[6] Cement beads have been used for intramedullary infections, however, they offer no mechanical stability and are difficult to remove after 2 weeks.[4]

Antibiotic cement impregnated intra-medullary nail can provide stability, is easy to remove and also provides all the advantages of the cement beads.[8,9] Use of antibiotic cement impregnated intra-medullary nail has been first reported by Paley and Herzenberg.[7]

Antibiotic cement impregnated intra-medullary nail should not be used in cases with bone defects > 4 cm, where it fails to achieve an adequate stability and infection control, and for such cases, procedures like Illizarov fixator along with bone transport can be used.[9]

Objectives

- To determine the functional outcome of infected non-union of femur and tibia treated with antibiotic impregnated nailing in patients attending Orthopaedic Department, Medical College Thrissur, Kerala with infected non-union from September 2016 to April 2018.
- To determine the functional outcome of antibiotic impregnated nailing in the treatment of infected non-union of femur and tibia.

METHODS

This is a prospective observational study done on 25 adult patients who were diagnosed to have infected non-union of femur and tibia at Government Medical College Thrissur from 01 September 2016 to 01 April 2018. Informed written consent was taken from all willing patients. The clearance from IEC/IRB was obtained (IEC no: B6 – 8772 / 2016 / MCTR date: 17.12.2016)

Inclusion Criteria

All adult patients diagnosed to have infected non-union of femur and tibia treated with antibiotic impregnated nailing.

Exclusion Criteria

Patients with infected non-union treated by other procedures. Patients with non-union with bone defects more than 4 cm, patients aged below 15 years, patients allergic to vancomycin and patients with non-union secondary to other causes other than infection.

Surgical Technique

A series of steps are involved in the surgical technique, each of which is critical for successful results.

Pre-Operative Evaluation

1. Complete blood count (CBC)
2. Erythrocyte sedimentation rate (ESR)
3. C - Reactive protein (CRP)
4. Culture and Sensitivity
5. Standard Radiographs

Debridement

This step involves thorough debridement of the infected bone and soft tissues. All the non-viable and infected tissues are debrided until bleeding viable tissue is present at the resection margins. Debrided tissues include the skin, soft tissues and bone. Specimens of the bone, soft tissues, and any purulent material present is obtained and sent for aerobic and anaerobic culture and sensitivity.[10] Adequate reaming of the intramedullary canal is an important step during the preparation, which helps in implanting larger diameter intra medullary nail which assures more stability. Osteotomy of middle third fibula is done as an accessory procedure when it is united and distracting the non-union site of tibia. Often used as adjunctive procedure which help

in deformity correction and surgical stabilization of tibia and also helps in compression at the fracture sites. Intact fibula can cause distraction or unweigh the physiologic forces seen in the tibia.[11] Concentrates physiologic forces (dynamizes) in tibia to augment mechanical healing environment.

Medullary canal and the wound is thoroughly lavaged with saline. The surgical team change their gowns and gloves. Before the preparation of antibiotic cement impregnated nail, the limb is prepared again and re-draped.

Antibiotic Cement Impregnated Kuntscher Nail Preparation

Separate sterile table is used to prepare the antibiotic cement impregnated nail. Guide wire is used to measure the K-nail length perioperatively. For tibia after selecting the Kuntscher nail of right length, Herzog's bend of 8 degrees in created 5 cm from the proximal end of K-Nail using a bench press. Reaming of the medullary canal is done to maximum diameter possible. Cement is coated 2 mm less than the diameter of the last reamer over a 8 mm or 9 mm K-nail.

Gentamycin bone cement of standard viscosity was used. Monomer was added to 40 gm bone cement only after thoroughly mixing 3 gm of vancomycin with cement. During the curing process when bone cement reaches doughy consistency, Kuntscher nail is coated and manually rolled up to a uniform diameter with bone cement. Smooth bullet shaped moulding of cement is done at the distal end of the K-nail, while the proximal eye is left open and bare of cement. Spotty areas of cement are smoothened. Excess cement is shaved off after checking the required diameter with Kushner diameter gauge and nail rerolled and smoothened. Diameter of the antibiotic cement impregnated K-nail is rechecked before cement sets. To prevent cement nail debounding, bone cement is allowed to set for 15 minutes before insertion for the monomer to evaporate.

Bone loss due to primary bone defect following fracture, following sequestrectomy or freshening of bone ends up to 3 cms fracture ends are opposed primarily.[12,13] Retrograde nailing of femur and anti-grade nailing for tibia is done after aligning the bone ends. During insertion to prevent nail cement debounding, care is taken to prepare appropriate diameter nail, adequate reaming of canal and allowing adequate time for cement setting and bonding with nail.

Bony Union

Assessment of bony union was mainly based on complete absence of pain and tenderness at the fracture site. Radiological union of fracture was based on the evidence of bridging periosteal and endosteal callus formation as three cortical contact.

Infection Control

Discharge from the wound, clinical signs of inflammation, and laboratory parameters like CBC, ESR, and CRP were used to determine the control of infection. Substantial clinical improvement of symptoms and signs, progressive decline in the sedimentation rate and C-reactive protein, and no additional radiographic signs of active infection were taken as signs of infection control. Micro biologic failure was defined as the continued isolation of the same infecting organism at the site of infection.

Exchange Nailing

If the infected non-union has been converted to a non-union without infection, if needed, exchange nailing is done without an antibiotic coating with a larger nail for giving additional stability. The IM nail coated with antibiotic can be left in situ permanently, if there is no infection and union has occurred. The intra medullary nail is exchanged for another antibiotic cement-coated K-nail, after a fresh pus culture and sensitivity, if both infection and non-union persists even after 6 to 8 weeks of the initial surgery. Wound is closed in layers over a suction drain after proper wound wash. Above knee plaster of paris (POP) slab is given for tibia, derotation boot given for femur. Primary closure of wound is done.

Post-Operative Protocol

All patients are put on plaster, groin to toe cast in case of femur, long leg cast in case of tibia. Systemic antibiotics are given according to last culture and sensitivity results. Wound inspected at intervals of 48 - 72 hours and repeat debridement was done whenever required. All blood investigations (CBC, ESR, CRP) are repeated after 2 weeks. If there is discharge, sent for culture and sensitivity and antibiotics titrated accordingly. Sutures were removed after 2 weeks and patient was discharged home. Clinical and radiological features were used to assess the progress of bony union. Progress of bony union was assessed at 6 weeks interval till union was sound. In case of tibia, gradual full weight bearing was permitted after 6 weeks after applying a patellar tendon-bearing cast. Cast is changed every 6 weeks after clinico-radiological assessment till there is bony union. For regaining ankle and knee mobility active physiotherapy was given till the range of movement was satisfactory. At regular biweekly intervals, complete blood count, erythrocyte sedimentation rate, and C-reactive protein levels were tested to record rising or falling shifts in values.

Until the results of culture and sensitivity from the samples sent at the time of surgery are ready, cefoperazone and sulbactam is administered during the first 24 to 48 hours after surgery. Based on these results systemic antibiotics are then changed, if necessary. Depending on organism involved and patients characteristics further treatment with oral antibiotics for 6 weeks to 6 months was initiated. Until there was no evidence of further infection, patients were followed. In patients with knee stiffness, knee mobilisation exercises were taught and encouraged, if needed active physiotherapy was given till the range of movement was satisfactory. Heel and sole rise was given for patients with limb shortening.

Bone Grafting

Routine bone grafting was not done along with the primary procedure. Bone marrow injection is preferred over open bone grafting.

Statistical Analysis

Data was entered and analysed using Microsoft Excel Application. Quantitative variables were expressed in mean ± S.D. Qualitative variables were expressed in proportions.

The final results were evaluated by Paley's bony and functional criteria.

Bony Criteria	Union	Infection	Deformity	Limb Length Discrepancy
Excellent	+	Nil	< 7 degree	< 2.5 cm
Good	+	With any 2 criteria		
Fair	+	With any one criterion		
Poor	-	With or without above criteria		

Table 1. Paley's Bony and Functional Criteria

RESULTS

The age distribution of the 25 patients ranged from 20 to 59 years in our study and the mean age was 31.6 years. Most of the cases are is between 0-39 years of age, i.e. 36 percent. Least number of cases was seen in the range of 50 to 59 years, i.e. 8 percent. The total number of cases included in this study is 25, among these 23 males and 2 females. Maximum number of cases happened to be males, i.e. 92 %. Out of 25 cases, only 5 cases were diabetic and were on oral hypo glycaemic agents.

		N (%)
Age group in years (n = 25)	20 - 29	7 (28)
	30 - 39	9 (36)
	40 - 49	7 (28)
	50 - 59	2 (8)
Gender (n = 25)	Male	23 (92)
	Female	2 (8)
Diabetes as a comorbidity (n = 25)	Yes	5 (20)
	No	20 (80)

Table 2. Socio-Demographic Profile

In this study, most of the patients had type 2 open injury initially 40 %. Initial injury status in the most of cases was open injury (19 case – 76 %). CRP was positive in 18 cases. Most of the cases culture was positive for *Staphylococcus aureus.*

		n (%)
Type of Fracture (n = 25)	Closed	6 (24.0)
	Type 1 open	2 (8.0)
	Type 2 open	10 (40.0)
	Type 3 open	07 (28.0)
CRP (n = 25)	Positive	18 (72.0)
	Negative	07 (28.0)
Antibiotic sensitivity (n = 25)	Staph. aureus	14 (56.0)
	MRSA	05 (20.0)
	Pseudomonas	04 (16.0)
	Klebsiella	02 (8.0)

Table 3. Clinical Parameters of the Patients

Out of 25 cases, in 23 cases, control of infection was achieved, which was 92 %. Out of 25 cases, 7 cases showed no evidence of fracture healing, they needed additional procedures. 18 cases showed evidence of fracture healing and accounted for about 72 % of total cases. Bone grafting was done in 10 (40 %) cases to accelerate fracture healing. Using Paley's bony criteria, out of the total 25 cases, 18 (72 %) cases showed excellent results, 3 (12 %) showed good results and 2 (8 %) showed fair results. 2 (8 %) were of poor outcome. 2 cases needed additional procedure like Illizarov / limb reconstruction system (LRS) fixation.

Bone Treated	No. of Cases	Infection Controlled
Tibia	14	13
Femur	11	10

Table 4. Control of Infection

Bone Treated	No. of Cases	Evidence of Fracture Union
Tibia	14	12
Femur	11	6

Table 5. Fracture Union

Complications

Case of infected non-union femur treated with antibiotic impregnated nail developed nail breakage after 3 months and was treated with interlocking nail of larger diameter as infection was controlled. One case bending of K-nail was noticed in shaft of femur and infection was not controlled and was treated by nail removal and LRS fixation. Distal and proximal migration was noted in one case each and nail cement debonding was also seen.

Complications	N (%)
Non-union persisting	7 (28 %)
Infection not controlled	2 (8 %)
Nail bending	1 (4 %)
Nail breakage	1 (4 %)
Proximal nail migration	1 (4 %)
Distal nail migration	1 (4 %)
Nail cement debonding	2 (8 %)

Table 6. Complications Encountered in Treated Patients

DISCUSSION

In infected non-unions and segmental bone defects, treatment methods that offer stability and control of infection to the bone to promote union is highly demanded. In 70 % of patients, Osteomyelitis is commonly polymicrobial. In our study and in the literature, the most common organism of infection is *Staphylococcus aureus*. Gentamycin and vancomycin are commonly used antibiotics for local delivery of antibiotics because of their broad spectrum activity, heat stability, and low allergenicity. Clinical and experimental studies show them to have good elution properties from bone cement, they can disperse to surrounding tissues with minimal systemic side effect and no deleterious effects on bone healing.

In our study, most of the cases belongs to the age group 20 - 40 (64 %), due to increased incidence of high velocity injuries in young individuals as results of road traffic accidents (RTA). Out of 25 cases, 23 cases were male indicating incidence of RTA higher among males. Most of the cases had open injury initially indicating chances of infected non-union. Most of the cases are type 2 and type 3 open injuries indicating degree of compounding as an important factor leading to infected non-union.

Control of infection in 23 out of 25 cases in our study is comparable to results of infection control in other studies. Evidence of fracture healing was noted in 18 cases out of 25. Remaining 7 cases which showed no evidence of fracture healing, out of which 5 cases showed union after bone grafting. There was delay in fracture healing in diabetic patients as compared to non-diabetic patients but control of infection was similar in both groups.

In 2 cases, there was no control of infection and no evidence of fracture healing and they needed nail removal and other procedures like Ilizarov / LRS fixation. All the cases where fracture union was visualised, infection was controlled.

Zhang Qiang et al. have shown bony union in only 11 out of 19 cases. Thonse et al. have shown bony union in 17 out of 20 cases. Paley et al. have shown that control of infection was about 85 % and bony union achieved in about 90 % cases by Ilizarov methodology. In the present study, bony union was achieved at an average of 20 weeks for tibia and 24 weeks for femur, is comparable with results shown by Han SK et al. of 26.4 weeks for tibia and 31.5 weeks for femur.

Pin site complications, difficulty due to obesity, which increases the risk of pin site infection, is associated with poor compliance with use of external fixators. These patients benefit from the antibiotic cement impregnated nailing**.**

CONCLUSIONS

Effective infection control and good stability to promote union is provided by antibiotic impregnated nail, traditionally provided by two separate procedures. It has good patient compliance and is advantageous over external fixators with complications of pin loosening/pin tract infections. Antibiotic impregnated nailing is safe, patient friendly, versatile procedure that could be adapted in hospitals easily. The method utilises commonly available implants, instrumentation, and materials in a highly cost-effective way to manage a complex problem**.** Antibiotic cement impregnated nailing is a simple, economical, and very effective procedure than the traditional methods in management of infected non-union of tibia and femur.

Data sharing statement provided by the authors is available with the full text of this article at jebmh.com.
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REFERENCES

[1] Toh CL, Jupiter JB. The infected non-union of the tibia. Clin Orthop Relat Res 1995;(315):176-191.
[2] Court-Brown CM, Keating JF, McQueen MM. Infection after intramedullary nailing of tibia. Incidence and protocol for management. J Bone Joint Surg Br 1992;74(5):770-774.
[3] Patzakis MJ, Zalavras CG. Chronic posttraumatic osteomyelitis and infected non-union of the tibia: current management concepts. J Am Acad Orthop Surg 2005;13(6):417-427.
[4] Thonse R, Conway J. Antibiotic cement-coated interlocking nail for the treatment of infected non-unions and segmental bone defects. J Orthop Trauma 2007;21(4):258-268.
[5] Wahlig H, Dingeldein E, Bergmann R, et al. The release of gentamycin from poly methyl methacrylate beads: an experimental and pharmacokinetic study. J Bone Joint Surg Br 1978:60-B(2):270-275.
[6] Wendt PP. Antibiotic-leaching from poly methyl methacrylate beads. J Bone Joint Surg Am 1994;76(6):951-952.
[7] Paley D, Herzenberg JE. Intramedullary infections treated with antibiotic cement rods: preliminary results in nine cases. J Orthop Trauma 2002;16(10):723-729.
[8] Selhi HS, Mahindra P, Yamin M, et al. Outcome in patients with an infected non-union of the long bones treated with a reinforced antibiotic bone cement rod. J Orthop Trauma 2012;26(3):184-188.
[9] Maini L, Chadha M, Vishwanath J, et al. The Ilizarov method in infected non-union of fractures. Injury 2000;31(7):509-517.
[10] Sancineto CF, Barla JD. Treatment of long bone osteomyelitis with a mechanically stable intramedullary antibiotic dispenser: nineteen consecutive cases with a minimum of 12 months follow-up. J Trauma 2008;65(6):1416-1420.
[11] Teitz CC, Carter DR, Frankel VH. Problems associated with tibial fractures with intact fibulae. J Bone Joint Surg Am 1980;62(5):770-776.
[12] Moehring HD, Gravel C, Chapman MW, et al. Comparison of antibiotic beads and intravenous antibiotics in open fractures. Clin Orthop Relat Res 2000;(372):254-261.
[13] Mendicino RW, Bowers CA, Catanzariti AR. Antibiotic coated intramedullary rod. J Foot Ankle Surg 2009;48(2):104-110.