MANAGEMENT OF INFECTED NON UNION OF LONG BONES BY ANTIBIOTIC LOADED PMMA CEMENT COATED NAIL AND BEADS

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DEPARTMENT OF ORTHOPAEDICS
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GOVERNMENT RAJAJI HOSPITAL
MADURAI.

CERTIFICATE

This is to certify that the dissertation entitled "**MANAGEMENT OF INFECTED NON UNION OF LONG BONES BY ANTIBIOTIC LOADED PMMA CEMENT COATED NAIL AND BEADS**" is a bonafide record of work done by **Dr. K. VIJAYANTH** in the Department of Orthopaedics and Traumatology, Government Rajaji Hospital, Madurai Medical College, Madurai, under the direct guidance of me.

Prof. Dr.V. RAVIRAMAN, M.S.ORTHO., D.ORTHO.,

Professor and Head of the Department
Department of Orthopaedics
Madurai Medical College and
Government Rajaji Hospital,
Madurai.

DECLARATION

I **Dr. K. VIJAYANTH,** solemnly declare that the dissertation entitled "**MANAGEMENT OF INFECTED NON UNION OF LONG BONES BY ANTIBIOTIC LOADED PMMA CEMENT COATED NAIL AND BEADS**' has been prepared by me under the able guidance and supervision of my guide **Prof. Dr.V. Raviraman, M.S.ORTHO., D.ORTHO., Prof & HOD,** Department of Orthopaedics and Traumatology, Madurai Medical College, Madurai, in partial fulfilment of the regulation for the award of **M.S. (ORTHOPAEDIC SURGERY)** degree examination of The Tamilnadu Dr. M.G.R. Medical University, Chennai to be held in March 2009.

This work has not formed the basis for the award of any other degree or diploma to me previously from any other university.

Place : Madurai

Date : **DR. K. VIJAYANTH**

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CONTENTS

INTRODUCTION

Ununited fractures of long bones are not only a complex surgical problem but also a chronic and at times debilitating condition. Infected non-union of long bones are not only a source of functional disability but also lead to economical hardship and loss of self esteem. Infected non-union has been defined as a state of failure of union for 6-8 months with persistent infection at the fracture site.

Infected non-union can develop after an open fracture, after a previous open reduction and internal fixation (ORIF) or as sequelae to chronic haematogenous osteomyelitis. The incidence also seems to be increasing especially in view of increasing high velocity trauma, which is more frequently treated with internal fixation.

It is difficult to treat infected non-union because of following reasons.

1. Previous surgeries would have resulted in cicatrisation of the soft tissue with an avascular environment around the fracture site.
2. The presence of dead bone or sequestrum at the fracture site prevents union.

3. Necrosis of bone near the non union site, to a considerable distance, due to thrombosis of blood vessels of Haversian canals.
4. Prolonged immobilization, multiple surgeries with fibrosis of the muscles leading on to a stiff joint / fracture disease.
5. The micro organism may develop resistance to the systemic antibiotic therapy and poses a problem in controlling the disease.

Soft tissue loss with multiple sinuses, osteomyelitis, osteoporosis, systemic antibiotic resistance all complicates treatment and recovery. These factors make an unfavourable milieu for fracture union. Even after prolonged treatment and repeated surgeries to correct this problem, the outcome is unsure and amputation may be the only alternative left.

Hence the treatment of non union of long bones associated with infection is a formidable challenge to the treating orthopaedic surgeons. Bony union is not usually obtained until the infection has been completely eradicated.

Three entirely different methods of treatment have been recommended for this difficult problem in the past.

These include the CONVENTIONAL OR CLASSIC, ACTIVE OR MODERN and treatment by PULSED ELECTROMAGNETIC FIELDS. The major disadvantages of these procedures being multiple surgeries, need of an external fixator for stabilisation, and associated poor patient compliance.

The current management of this kind of infection consists of two main objectives. Infection control which is usually achieved by nail removed with debridement, lavage of medullary canal, local delivery of antibiotics by antibiotic impregnated bead chains and fracture union, which usually is accomplished by alternative fixation mostly external fixation.

The principle of antibiotic impregnated beads is to

i) Fill the dead space and

ii) Deliver high concentration of antibiotic to infected site.

The concept of antibiotic impregnated PMMA spacer originated in prosthetic joint infection. With very good results in prosthetic joint infection, these antibiotic impregnated PMMA spacer

indication were extended to infected non union of diaphyseal fractures.

The advantages of antibiotic impregnated PMMA coated nails and beads in the treatment of infected non union of long bones being increased local concentration of antibiotics and stable internal fixation, which controls infection and promotes bony healing at a better rate with good patient compliance.

AIM

- To discuss the biological advantage of antibiotic cemented nailing and beads in the management of infection non union of long bones.
- To evaluate the clinical outcome of the study and discuss the results of cases with infected non-union of femur and tibia managed by antibiotic impregnated PMMA cemented Rods and Beads.

CAUSES AND CLASSIFICATION OF NON UNION

Causes:

In 1986 FDA panel defined Nonunion as ‘established when a minimum of nine months have elapsed since injury and the fracture show no visible progressive signs of healing for 3 months’. But that criterion cannot be applied to every fracture. A fracture of shaft of long bones should not be considered as non-union until at least 6 months after the injury, because often union requires more time, especially after some local complications such as an infection. Non union can result from the following causes.[7]

1. Excess motion

   Due to inadequate immobilization

2. Gap between fragments

   a) Soft tissue interposition

   b) Malposition or over riding or displacement of fragments

   c) Loss of bone substance

   d) Distraction by hardware or traction.

3. Loss of blood supply

   a) Damage to nutrient vessels

b) Excessive stripping or injury to periosteum and muscles

c) Free fragment, severe communition

4. Infections

a) Bone death (sequestrum)

b) Osteolysis (Gap)

c) Loosening of implants

5. General (pre disposing factors)

Age, nutrition, steroids, radiation, anticoagulants, DM, immunodeficient states etc.

CLASSIFICATIONS

There are various classifications available for non-union and infected non-union in the literature.

I - Judet, Muller, Weber and Cech classified non-union broadly into two types. They are

a) Hyper vascular (hypertrophic) the ends of the fragments are capable of biological reactions

b) Avascular (atrophic), the ends of the fragments are inert and incapable of biological reaction.

Hypervascular / Viable / Hypertrophic non-union further subdivided into

1) Elephant foot type
2) Horse hoof type
3) Oligotrophic type

Avascular nonviable / atrophic non-union further subdivided into

1) Torsion wedge
2) Communited
3) Defect
4) Atrophic

II - Paley et al divided non union clinically and radiologically into 2 major types

Type A (Bone loss < 1 cm)

A1 - Non union with a mobile deformity

A2 - Nonunion with a fixed deformity

A2 -1 Stiff non-union without deformity

A2 -2 Stiff non-unions with a fixed deformity

Type B (Bone loss > 1 cm)

B1 - Nonunion with a bony defect

B2 - Nonunion with loss of bone length

B3 - Nonunion with bony defect and loss of bone length

This classification system is further modified by the presence or absence of infection.

III - Maurizio Catagni's classification

A1 - Non infected mobile non-union

A1 - Non infected stiff hypertrophic non union without deformity

A3 - Non infected hypertrophic non-union with deformity

B1 - Non infective non-union with bone defect of up to 5 cms

B2 - Non infective non-union with bone defect exceeding 5 cms

B3 - Non infective non-union exceeding 10cms with local scarring

C1 - Infected non-union with atrophy

C2 - Infected non-union with hypertrophy without deformity

C3 - Infected non-union with hypertrophy and deformity

C4 - Infected non-union with bone gap of less than 5 cms

C5 - Infected non-union with bone gap between 5 and 10 cms

C6 - Infected non-union with bone gap exceeding 10 cms

IV - The University of TEXAS Classification

Based on the location of infection and modified by immune competence of the host.

Type 1 : Intramedullary

Type 2 : Superficial

Type 3 : Local

Type 4 : Diffuse with segmental bone loss

Type A : Healthy immune system

Type B : Local or systemic compromise of immune System

Type C : Severe compromise of immune system

V - WIELAND'S Classification

Type 1 : Bone exposed and soft tissue infection present

Type 2 : Circumferential – cortical and endosteal infection Present

Type 3 : Cortical and endosteal infection combined with segmental bone loss

VI - AO - Classification :

1) Infected non draining non-union (Active / Quiescent)

2) Infected Draining non-union

VII - KULKARNI'S Classification

Classification of infected non-union is based on the severity of infection, apposition of fragments, presence or absence of deformity.

Type 1 : Mild infection

- Beads of pus on pressing
- Fragments in alignment
- With or without an implant
- No gap
- No deformity
- No shortening

Type 2 : Moderate infection :

- Fragments in apposition
- No gap or gap < 2 cm
- No deformity
- No shortening
- Moderate infection with a large or small wound

Type 3 : Severe Infection

- Pouring pus
- Gap > 2 cms
- With deformity
- Shortening > 2 cms

PATHOPHYSIOLOGY OF INFECTED NONUNION

Infection per se, does not cause non-union, as union has been shown to occur in the presence of active infection. Uncontrolled infection, however causes non-union, predominantly because purulent material dissects under pressure within the intramedullary canal and along the subperiosteal surfaces of bone, resulting in bone necrosis. The inflammatory response to the infections process may also lead to an excessive remodelling response causing osteolysis, which further slows the rate of union. [1,2,3]

Pathophysiology of infections after internal fixation of fractures:

Infection complicating internal fixation of fractures is a serious complication that is difficult to treat whenever metallic implants are implanted in vivo, successful bio integration requires that host cells colonize the highly reactive implant surface. Bacteria such as staphylococci can also became adherent to metallic or polymeric implants and will compete with host cells for colonization of the implant surface. Once adherent these bacteria form a bio film and undergo phenotypic changes that make them resistant to the normal host immune response as well as to antibiotics. Furthermore,

metallic implants themselves cause specific deficits in the function of the local immune system that may render the host response to infection inadequate. Any associated soft tissue injury causes greater impairment of local immune function. Despite the potentially detrimental impact of internal fixation, fracture stability is of paramount importance in achieving fracture union and in preventing infection. It has been demonstrated in animal models that contaminated fractures without internal fixation develop clinical infection more commonly than similar fractures treated with internal fixation at the time of colonization. Because of the potential for infection whenever internal fixation is utilized appropriate prophylactic antibiotic coverage for staphylococci and gram negative organisms should be provided. Open wounds and severely damaged soft tissues require aggressive management so that a viable soft tissue envelope is maintained around the implant. Host factors such as smoking and malnourishment should be corrected. Early diagnosis and aggressive treatment of implant related infection with antibiotics, debridement and maintenance of stable internal fixation are essential to successful treatment. [29,30]

Bacterial adherence to biomaterials and tissue. The significance of its role in clinical sepsis.

A study by AG Gristina and JW costerton

The direct examination of tissue and biomaterials from prosthesis related infections of 25 patients showed that the causation bacteria grew in glycocalyx enclosed bio films that were adherent to surface of biomaterials and tissue in 76%. This high rate of recovery of adherent bio film mediated growth suggests that the process occurs commonly in the presence of a foreign body or biomaterial related infection. Because of the adherent mode of growth of the infecting organisms, accurate microbiological sampling was difficult. The analysis of swabs of excised tissue and of prosthetic surfaces often yielded only one species from what was a polymicrobial population based an election microscopic studies.

INVESTIGATIONS

1. Diagnosis of Infection in ununited fractures

Combining imaging with Indium – 111 labelled leukocytes and technetium – 99^{m} methylene diphosphonate were used were compared with the results of cultures of open bone at 102 sites of delayed union and non-union, to determine the effectiveness of this combination as a preoperative indicator of osteomyelitis.

A sensitivity of 86%, specificity of 84% an accuracy of 82%, a positive predictive value of 69% and a negative predictive valve of 94%.

2. ESR

Measurement of increased rate of setting of erythrocytes is an important lab test in evaluation of disease activity in patients with infections.

Done by Westergren method

Normal valves are 0-9 mm per hour for men, 0-20 mm / hr for women. In routine orthopaedic procedures, maximum of 25 to 40 mm / hr is reached in 4 days which gradually decreased to normal over 1-2 weeks.

3. C – Reactive protein

An acute phase protein that can be used to follow the course of acute infections

It rises and falls faster than ESR

10 mg per litre is used as the threshold for THR infection, using this threshold the sensitivity and specificity are both about 90%

4. WBC count

5. X ray - AP view & Lateral view

HISTORY OF INFECTED NONUNION TREATMENT

Considerable judgement is required to treat a non-union of an infected fracture. There entirely different methods of treatment have been most of recommended for this difficult problem.

1. Conventional or classic method
2. Active or modern method
3. Pulsed electromagnetic fields

Ilizorov method is a more recent method of treating infected non-union that has similarities to both the conventional and active methods. [6,7]

1. Conventional Treatment :

The conventional treatment is used for many decades.

The object of conventional treatment are to convert an infected and draining non-union into one that has not drained for several months and then to promote healing of the non-union by bone grafting. This method of treatment often requires 1 or more years to complete and usually results in stiffness of adjacent joints.

The skin over the bone is made as nearly normal as possible.

3 operations are necessary to provide this type of skin.

Stage I :

Wound is thoroughly saucerised and all foreign and infected or devitalized materials are removed to provide a vascular bed. Any gross overlapping and displacements of the fragments are corrected. Fixation is done either by internally or externally. Antibiotics are used both parenterally and locally after surgery.

Stage II :

After 4-7 days when a thin layer of granulation tissue has covered the wound, a split thickness skin graft is applied. The split graft is replaced by a full thickness pedicled skin graft 4-6 weeks after the wound has healed from the operation.

Stage III :

When the clinical sign of infection have subsided, the skin over the bone is good and non-union persists, bone grafting must be considered. Controlling infection before attempting bone grafting always has been a sound clinical principle in the conventional treatment of non-union.

2. Active treatment :

The object of active treatment is to obtain bony union early and preserve motion in the adjacent joints. Judet, Patel, Weber and

Cech described this method and much of the following is taken from their reports. The first step is restoration of bony continuity. This takes absolute priority over treatment of the infection. The non-union is exposed through the old scar and tissues. The ends of the fragments are then decorticated subperiosteally forming many small osteoperiosteal grafts, any graft that become detached are discarded. Next all devitalised and infected bone and soft tissues are removed. Then the fragments are aligned and stabilised usually by an external fixator. Compression is applied across the non union if possible. Weber and Cech then inserted autogenous cancellous bone grafts. Internal fixation with a plate is used only when drainage has already ceased, and then the approach is away from the area of old drainage or when no other method of fixation is possible and the infection is mild. Finally a tube for suction drainage is inserted and as much of the wound as possible is closed, any remaining open area is covered by a biological dressing, systemic antibiotics are given.

If necessary for union, a second decortications with or without addition of cancellous iliac bone grafts is carried out.

Disadvantage :

Both conventional and active methods had their own disadvantages and faded over time.

1. Required multiple procedures
2. Poor patient compliance.
3. Joint stiffness.

Electric and Electromagnetic stimulation :

External electrical stimulation is especially advantageous in infected non-union management or when surgical intervention is contraindicated. At least 3 electrical and electromagnetic methods are available for the treatment of non-union. These methods are either invasive, requiring the implantation of electrodes or semi invasive requiring percutaneous application of multiple electrodes. Devices that use inductive coupling differ in their configuration some try to recreate the Helmholtz configuration and others use a U shaped coil. 80% united if the device was used for more than 3 hours a day. Nonunion healed as readily as those from 9-12 months. Also infected nonunions were as likely to heal as noninfected nonunions, and fracture gaps up to 1 cm did not adversely affect the outcome. De Hass et al also found that a high percentage of infected

non-union healed with electrical stimulation compared with uninfected nonunions. However they recommended that infected fractures be debrided before electrical stimulation.[7]

Ilizorov Method :

According to Ilizorov, to eliminate infection and obtain union, vascularity must be increased. In his approach this is achieved by corticotomy and the application of his circular external fixator. Catagni reported that, although union was obtained, infection was not always eliminated. For atrophic nonunions with diffuse infection or sequestrated bone open resection of the infected segment is performed and bifocal compression is used.[7]

Disadvantages of Ilizorov method :

1. Poor patient compliance
2. Cumbersome procedure
3. Pin tract infections
4. Muscle contracture and joint stiffness
5. Systemic antibiotic toxicity

Polymethylene methacrylate (PMMA) Antibiotic Beads :

Antibiotic impregnated PMMA beads also can be used to treat infected nonunions. Head stable antibiotics such as tobramycin and gentamycin can be mixed with PMMA and used locally to achieve 200 times the antibiotic concentration achieved with iv antibiotics. Calhoun et al reported the use of antibiotic impregnated PMMA beads in conjunction with debridement in the management of infected nonunions. In their series a group of patients treated with debridement and implantation of antibiotics beads for 4-6 wks were compared with patients treated with parenteral antibiotics for 4 weeks after debridement. Bone healing and stabilisation were treated according to local conditions. Infection was successfully arrested in 89.3% of patients who were treated with gentamicin PMMA beads and in 83.3% in patients who received in antibiotics.[4,5,6,7]

PRINCIPLES IN THE MANAGEMENT OF INFECTED NONUNION BY ANTIBIOTIC LOADED PMMA CEMENTED ROD AND BEADS

Preliminary Steps :

The principles of treatment are infection control, stabilisation of fracture, soft tissue coverage, and bone grafting of ununited fractures and large bone defects.

Infection control includes irrigation and debridement, culture and sensitivity and antibiotic therapy. In chronic osteomyelitis obtain aerobic, anaerobic and fungal cultures. Recent studies have advocated taking of multiple deep cultures from purulent material, soft tissue, and Marrie and Costerton postulated that different organisms may be growing in isolated microenvironments. Sampling differences and bacterial viability may influence the culture results.

Stabilization of the ununited fracture or non-union is essential. Soft tissue coverage may require the use of local muscle flaps and free vascularised muscle flaps for soft tissues defects. These may also be helpful by bringing in a new blood supply, which is

important in host defence mechanisms, antibiotic delivery and osseous and soft tissue healing.

Surgical Consideration :

Tourniquets :

Apply a tourniquet whenever possible except in patients with sickle cell disease or significant peripheral vascular disease. The tourniquet improves haemostasis and they facilitate identification of the infection process. In acute cases with swelling, cellulitis, or abscess formation, elevate the extremity for several minutes before inflating the tourniquet. In chronic osteomyelitis without significant cellulitis or abscess, use an elastic bandage to extravasate the extremity before inflating the tourniquet. [6,7]

Debridement :

Thorough debridement of all sequestra and necrotic and desiccated bone is essential. Do not remove viable infected bone, so as not to create large bony defects.

Clinically dried out, exposed, desiccated bone is darker than normal and should be debrided. Necrotic bone that has not been exposed may appear at surgery more yellowish than viable bone, which is whitish.

The main finding is that viable bone bleeds, whereas necrotic bone does not. Use of an osteotome to superficially shave the outer cortex of the questionable bone results in small areas of punctuates bleeding. Evacuate all pus and abscess and remove all necrotic and infected soft tissue. [6,7]

Irrigation :

Use copious amounts of irrigating fluid, which cleanses the area of purulent exudates, loose soft tissue and bony fragments and decreases the bacterial count.

With regard to delivery of irrigation, high pressure pulsatile lavage appears to be most effective for removal of bacteria and other contaminants. Sterile saline solution either alone or with an additive is commonly used for irrigation. The available additives are divided into 3 general categories.

I Antiseptics - Povidone Iodine
- Chlorhexidine gluconate
- Hexa chlorophene

II Antibiotics - Bacitracin

III Soaps

Soaps remove microbes instead of killing them, and have least injurious effect on osteoblasts and osteoclast. The irrigation volume

varies. From the available evidence, it is not possible to recommend any particular additive for the irrigation of medullary canal.

We used 10 litres of normal saline for irrigating the infected wounds, 2 litres of diluted 5% povidone iodine 1: 20,000 solution as the final irrigating solution. Povidone Iodine is a broad spectrum microbicidal agent, acts by iodinating and oxidizing microbial protoplasm.

After irrigation, the medullary canal is reamed up to its maximum capacity to allow fresh bleeding and for maximum space for the prepared nail to be inserted. [6,7]

Wound Management :

The decision to leave a wound opens or to close it, requires careful judgement. In the majority of acute infections and in all cases in which there is associated abscess formation with cellulitis and swelling the wound should be left open. In some cases of early post operative infection, the wound may be closed over drainage tubes as long as the wound is thoroughly clean and the infection is not anaerobic.

In some cases in which bone or metal will be exposed if the wound is left open, a partial closure over the bone or metal may be

desirable as long as an adequate pathway has been provided for drainage. When there is any doubt, it is safest to leave the wound open. If the wound is closed, the wound site must be examined daily for any signs of infection, if such signs appear the wound must be opened.

Many wounds heal nicely by secondary intention. In case of large wounds or when delayed closure is preferable, do not attempt closure until two criteria are met.

First, the wound should appear clinically healthy with clean granulating tissue and without any purulent exudates or necrotic tissue. If infected necrotic tissue are present redebride the wound until it appears healthy. Second, once clinical appearance of the wound is clear, take quantitative tissue culture and do Gram stains. Wounds with either a positive Gram stain or quantitative tissue cultures with a bacterial count greater than 10^5 organisms should never be closed. (A positive gram stain implies a bacterial count of greater than 10^5 organisms)

With experienced surgical teams, tissue culture is not routinely performed. It has been our practice to do a thorough initial

debridement followed by an en bloc excision of the wound at closure or muscle transfer. [6,7]

Drains :

When the wounds are closed, silastic (Jackson-Pratt) or polyethylene (Hemovac) drain may be used. Penrose drains, made of rubber, are the most reactive, and if left in for long periods can cause foreign body granulomas. Do not use Penrose drains in orthopaedic infection management.

Remove the suction drain in 48-72 hrs. The drain allows the removal of all hematoma and tissue fluid and the collapse of the potential dead space. The drain should be removed under sterile conditions and the tip cut off and sent for culture and sensitivity tests.

In general a positive culture of the drains tip is a bad prognostic sign. It means that bacteria remain behind. [6,7]

Wound Packing :

The purpose of leaving a wound open in to allow drainage. Make certain that, when packing wounds with gauze or other materials packing does not obstruct drainage. If it does, purulent exudates will be retained in the wound, possibly causing tissue

breakdown and necrosis with secondary cellulitis or even abscess formation. It is best to put wicks perpendicular to the open wound to allow free drainage. Wicks can be either povidone iodine soaked gauze, plain gauze or fine mesh gauze. The size varies with the size of the wound. The ends of the wicks should always protrude through the skin edges to allow easy access and removal and to prevent retention. [6,7]

Antibiotic loaded PMMA Beads & Intramedullary nails.

Materials used

1. Bone Cement:

Bone cement are orthopaedic acrylic radioopaque sterile cements that allow an immediate and stable fixation if surgical implants into the bone. [20,21]

Available as

1. Standard viscosity (digital uses)
2. Low viscosity (syringe use)

Bone cements are composed of two components

1. The polymer in powder form
2. The monomer in liquid form

Powder

1. Polymethyl methacrylate – polymer
2. Benzoyl peroxide – initiates polymerisation
3. Barium sulphate – Radio opaque contrast medium for X ray examination

Liquid

1. Methyl methacrylate – monomer
2. Butyl methacrylate – Co monomer
3. N, N dimethyl p – toluidine – promote cold curing of the finished therapeutic compound
4. Hydro quinine - prevent premature polymerisation

Preparation of the Bone cement:

To mix, empty the contents of the packet containing the powder into a sterile inert mixing device. The liquid from the ampoule is added to the powder. Stirring is done until a dough like mass is formed. The dough like mass is ready for manipulation. The mixing and manipulation process should be at least 4 mins. The completion of polymerisation occurs with an exothermic reaction with considerable liberation of heat. Temperature occurring during polymerisation has been reported as high as 110^{o} C. [22,23,24]

Hardening time:

From the start of mixing, the final hardening occurs in standard viscosity bone cement → 7.5 – 8.5 min

Low viscosity bone cement → 9.5 – 10.5 min

Adverse reaction:

Most serious reaction

1. Cardiac arrest
2. Myocardial infarction
3. Pulmonary embolism
4. Cerebrovascular accident

Most frequent reactions

1. Transitory fall in BP
2. Thrombo phlebitis
3. Haemorrhage
4. Loosening and displacement of prosthesis
5. Surgical wound infection
6. Trochanteric bursitis
7. Trochanteric separation

Storage:

Store in dark below 25^{o} C

Flammable – keep away from the source of ignition

Pack presentation:

- Sterile packet contain 20 gm or 40 gms of sterile powder polymer
- Sterile ampoule containing 10 ml or 20 ml of sterile liquid monomer. [23,24,25]

2. Antibiotics in Bone Cement:

The infection rate in early series was up to 5% or more. The initial contamination, soft tissue injury immunity status of the patient, and theatre sterility all affect the outcome of surgery. With increasing experience the infection rate is now down to 1-2 % in the average orthopaedic unit.

Short courses of perioperative systemic antibiotics have helped to reduce postoperative sepsis. In 1969, Buchholz and Engelbrecht first proposed a totally different approach incorporating antibiotic powder directly into the bone cement. This work is supported by the

data from Marks, Nelson and Lautenschlager and invitro pharmacokinetic studies of Wahlig and Dingeldein (1980).

Mechanical testing of the antibiotic impregnated bone cement confirmed that the antibiotic when incorporated in the amounts usually used for clinical purposes had no significant influence as the strength of the bone cement both in comparison and tension. [26,27]

Antibiotic impregnated bone cement has been used for long time in orthopaedic joint replacement surgeries. Now we have tried this in infected non union of long bones.

Antibiotic Agents:

Antibiotic agents that are heat stable, available in powder from and active against suspected pathogen are appropriate choices for local therapy. Amino glycosides and vancomycin accept these criteria.

Fluroquinolones, tetracycline and polymyxin B, are broken down during the exothermic process of cement hardening and therefore cannot be used with PMMA bone cement.

IDEAL ANTIBIOTIC

1. Should be available in powder form
2. Broad spectrum – effective against gram positive cocci and MRSA
3. Thermo stable
4. Less toxic
5. Less used – less resistance
6. Cost effective
7. Non allergic

Antibiotics commonly used

1. Vancomycin
2. Gentamicin
3. Tobramicin
4. Cefazolin
5. Clindamycin
6. Ticarcillin
7. Teicoplanin
8. Erythromycin
9. Colistin
10. Cefotaxime
11. Amphotericin B

Microorganism in infected non-union:

Currently most infections are cause by gram positive cocci and gram negative bacilli. However methicillin resistant staphylococcus

aureus (MRSA) has recently emerged as a potential cause of infection.

Vancomycin:

It is a glycopeptide antibiotic assumed special significance due to its efficacy against MRSA, Strep viridians, Enterococcus and Clostridium difficile. It is bactericidal to gram positive cocci, Neisseria, Clostridia and Diphtheroids. [27,28]

It acts by inhibiting bacterial cell wall synthesis.

It is not absorbed orally. After iv administration it is widely distributed, penetrates serous cavities, inflamed meninges and is excreted by glomerular filtration, with a t ½ of 6 hours.

Toxicity:

1. It causes plasma concentration dependent nerve deafness
2. Kidney damage is also dose related
3. Skin allergy, thrombophlebitis, fall in BP, are other problems.
4. Rapid iv injection has caused chills, fever, urticaria, intense flushing called **Redman syndrome**. Available as 500 mg / vial Inj.

- Vancomycin has much slower and more consistent elution characteristics.
- As much as 4 gms of vancomycin can be used for batch of cement.
- In the study by Evans et al, the authors used 4 gms of vancomycin per 40 gms batch of cement in 54 periprosthetic joint infections.
- At 2 years follow up there were no renal, vestibular or hearing changes.
- Note that the cost for a 1 gm vial is about 40 US dollars.
- In the report by Springer et al total antibiotic load of 10.5 gms of vancomycin was clinically safe, with no evidence of acute renal insufficiency or other systemic side effects.[28,29,30]

Antibiotic loaded beads were first introduced by Klaus, Klemm for use on osteomyelitis. Henry, Seligson and Ostermann introduced a physician made antibiotic bead pouch for use in open fractures. Microbe specific antibiotics can be added to either palacos or simplex PMMA. The antibiotic elution has been reported by some investigations to be better for palacos than simplex. Although

most antibiotics may be added to PMMA depending on the microbial sensitivity results, vancomycin, tobramycin and other amino glycosides are the most commonly used antibiotics.

We used 2 gms of vancomycin to 40 gms of Palacos PMMA, an amount sufficient to make enough bead chains to fill large defects. We made 6 or 7 mm beads string on 24 or 26 mm stainless steel wire. Bead size should be small because increased surface area allows for better antibiotic elution. The advantages of the antibiotic beads used in this fashion are high local antibiotic levels with low systemic toxicity and less chance for secondary contamination because the wound is covered. Also important is patient comfort, as dressing changes are not required, and there are decreased requirements for wound care.

Preparation of Antibiotic Loaded Cemented Rods:

2 gms of vancomycin powder is mixed with 40 gms of PMMA polymer powder, the liquid monomer is added in a stainless steel bowl, mixed thoroughly until it forms a doughy consistency. In the mean time the debridement and irrigation of medullary canal is done. K nail or interlocking nail of size 2 mm smaller than the diameter of medullary canal reamed is selected. The vancomycin mixed PMMA

bone cement is coated on the nail surface, rolled over to create a smooth surface, the excessive bone cement is cleared off from the surface by using K nail gauze, so that an ultimate antibiotic cemented nail of diameter equal to that of the medullary canal reamed is prepared. The nail is allowed to set till it gets hardened. [8,9,10,11,12,18]

Preparation of Antibiotic Loaded Cement beads:

When the Vancomycin mixed PMMA bone cement attains its doughy consistency it is rolled over manually into balls of 6 mm to 7mm diameter. A string of 30 beads are made over 20 or 22 gauze stainless steel wire. They are allowed to get set, and thus beads are made ready for implantation. [16,17,18,19]

Advantages of Antibiotic loaded Cement beads and Rods:

1. High local concentrations of antibiotic - 200 times greater than systemic drug delivery. (Ref. Campbell's Text book of Orthopaedics, 10th edition, volume 3, page 3136.)
2. Least systemic toxicity
3. Primary wound closure, reduced post operative morbidity and early rehabilitation started.

4. Painful inflammatory response subsides rapidly and there is increased patient comfort.
5. No daily dressing, as wound is closed.
6. Long stay in hospital avoided thereby decreased hospital acquired infections.
7. Cost effective [12,13,14]

Insertion of Antibiotic cemented Rods and beads implantation

The prepared antibiotic cement loaded nail is inserted into the medullary canal of femur or Tibia through the same portal of previous surgery. Care must be taken, not to insert the nail before it hardens or else the cement may get debonded from the nail.

The prepared beads are folded and packed within the soft tissue around the infective foci. Primary wound closure is done. The antibiotic is leached from the PMMA beads and rod into the postoperative wound hematoma and secretion, which acts as a transport medium. The use of suction drains is debatable, because their presence may diminish the concentration of antibiotic in the wound hematoma.

Beads Removal:

Short term - removed within 10 days

Long term - Left up to 80 days

We recommend removal of PMMA beads at 4-6 weeks

Rationale of early removal:

Local bactericidal antibiotic level lasts only between 2-4 weeks after implantation.

Once all the antibiotics has leached out of the bead, a foreign body remains that may be colonised by glycocalyx forming bacteria. PMMA also has been shown to inhibit local immune response by impairing various phagocytic immune responses.

Bone grafting:

Early cancellous bone grafting is recommended in few cases where there is no evidence of any purulent discharge. Cancellous bone grafting can be performed as early as 4-6 weeks after initial surgery along with beads removal. The autografts are considered to be osteoinductive as well as osteoconductive. Posterolateral bone grafting (Harmon's procedure) is a special procedure applied in infected non-union of Tibia with indolent ulceration and draining sinuses anteriorly. Bone morphogenic protein (BMP) contains bone growth factors necessary to stimulate new bone formation. It triggers a cascade of cellular events that resemble endochondral ossification in an ectopic location. [6,7]

Treatment of Complications:

For cases, with persistent infection, the antibiotic cemented nails were removed after bony union within an average period of 16-24 months. The patients were followed and there were no evidence of further infection. In a few cases we did sequestrectomy at the time of nail removal. In patients with knee stiffness knee mobilisation exercises was encouraged and in patients with limb shortening heal and sole rise was given. In cases with difficulty in beads removal the patients were followed up for 12 months and beads were found to be inert and there were no evidence of infections so the left over beads were not removed.

REVIEW OF LITERATURE

1. Calhoun et al reported the use of antibiotic – impregnated PMMA beads in conjunction with debridement in the management of infected non-union.

In their series a group of patients treated with debridement and implantation of antibiotic beads for 4-6 weeks was compared with patients treated with parenteral antibiotics for 4 weeks after debridement. Bone healing and stabilization were treated according to local conditions. Infection was successfully arrested in 89.3% of patients also were treated with gentamicin PMMA beads and in 83.3% in patients who received IV antibiotics.

2. Chirurgie de la main vol 26, Issues 4-5 Aug-Oct 2007, page 243-246. Institute of orthopaedics and traumatology Prof. Dr.Carlos E. Otto lenghi "Hospital Italiano Buenos Aires, Argentina.

Study : Infected non-union of humerus treated with an antibiotic cement rod. Case report : the authors present a case of an infected non-union of humerus treated initially with reaming of the medullary canal followed by the introduction of an antibiotic impregnated IM rod. Reconstruction of humerus with bone graft was done at second stage. The final results were healing of the fracture and a good

functional result with no evidence of recurrence of infection at a 25 months follow up.

3. NaG KH, Park SJ, Han SK, Sung HS, Choi NY, Department of orthopaedic surgery, St Paul's hospital, The Catholic University of Korea, college of Medicine, Seoul, Korea.

J. Korean Fracture SOC 2003, Oct 16 (4) : 511-518. Study : Treatment of infected non-union of long bones : Comparison between fixation by antibiotic cement loaded IM nailing and fixation by antibiotic cement loaded external mono fixator.

Among the 15 case of infected non-union of long bone shaft, 6 cases treated with fixation by antibiotic cement coated IM nailing and 3 cases treated with fixation by IM nailing along with antibiotic cement beads insertion were divided as group I (n=9) and other 6 cases treated with fixation by external monofixator along with antibiotic cement beads insertion were divided as group II (n=6)

Conclusion : In the treatment of infected non-union of long bones with mild bone loss and shortening of less than 1 cm, the fixation by IM nailing with use of antibiotic cement prefers to the fixation by external morvo fixator with the use of antibiotic cement in the

velocity of union, control of infection and in clinical aspects such as alignment, early ambulation and joint stiffness.

4. Gianluca Giavaresi Velonica Borsari, Milena Fini, Roberto Giardeno, Vitlorio sambri, Paolo Gaibani, Revizo soffiatti J orthop Res. : 2008 Jan 9.

Study : Preliminary investigations as a new gentamicin and vancomycin coated PMMA nail for the treatment of bone IM infections an experimental study in rabbits.

To evaluate a new gentamicin – vancomycin impregnated (2:1) PMMA coated nail drug delivery device to treat bone and IM infected MRSA was used to induce femoral osteomyelitis in 20 Newzealand male rabbits. 4 weeks after inoculum, the animals were submitted to debridement of infected femoral canal.

Group I : Insertion of a steel IM nail

Group II : Insertion of GM vancomycin impregnated PMMA Nail

Group III : No therapy

Group IV : No fixation, 1 week systemic antibiotic therapy with teicoplanin IM

At 7 weeks after inoculum the radiological score showed that the lowest and best cure was obtained in Group II.

5. Susan M. Rapp orthopaedics Today 2008, 28: 24

Study : Antibiotic coated rods treated infection, stabilize defects

In 2002, co way devised the technique and in 2004, she decided to study the initial results in 32 cases. She fills silicone tubing with an inner diameter of 12-5 mm or less with cement, places the rod inside, lets the cement set and then cuts away the tubing.

Cultures showed most patient had MRSA. Investigations mixed 3.6 gm of Tobramycin and 1 gm of vancomycin into a 40 gm package of bone cement. Conway found nails coated in antibiotic cement were an effective treatment with a 73.1% success rate.

6. Zhang Qiang, Pan Zhijun, Xu Jian Jie, Littang, Li Jian birg, and Li Fang cae. Archieves of orthopaedic and Trauma surgery volume 127, Dec 2007.

Study :

We received 19 infected patients also underwent removal of the nails, excision of sinus tract, debridement of the canal and insertion of the rods. No recurrent infection occurred in 18 cases, 11

cases achieved bony healing, 6 cases showed partial union. We conclude that antibiotic cement rods could be a relatively effective, simple and inexpensive method of treating intramedullary infections after nailing.

7. Han SK, NT,, Park SJ, Lee SK, Jang G, Lee IJ, J. Korean orthop Assoc 2000 Oct 35 (5) : 699-703, Korean.

Study :

Our study was again to evaluate the results of treatment of antibiotic cement coated unreamed nailing for infected non-union of long bones 10 cases, 6 femurs and 4 tibia were included in our study. All of the 10 cases had bony union. Union time was average 31.5 weeks in femur and 26.4 in tibia. Early weight bearing ambulation and motion of adjacent joint were beneficial.

8. Thonse R. Conway J. Musgrove Park Hospital, Belfast ; United Kingdom. Journal of orthopaedic Trauma 2007 Apr 21(4) : 258 – 68. www.ncbi. n/m rib. Govt / pub med / 1741 4554.

Study :

Chronic infection of bone with non union is traditionally treated by a 2 stage procedure involving initial debridement and antibiotic delivery and then definitive internal fixation. A technique

with antibiotic cement coated. Interlocking nails are prepared in operating room with the use of nails and materials that generally are available is here in described. This technique was used in a series of 20 patients. In 17 patients, the goal of bony union was achieved (85%). In the remaining 3 patients (15%) the goal of control of infection was achieved with stable non union (1 patient) and stable non-union with cement spacer (2 patients) 4 patients (20%) experienced cement nail debinding during removal.

9. Qiang Z, Jun PZ, Jie XJ, Hang L, Bing LJ, Cai LF. Arch Orthop. Trauma Surg. 2007, Dec ; 127 (10) ; 945-51. E Pub 2007, Mar 27.

Study :

Use of antibiotic cement rod to treat intramedullary infection after nailing : preliminary study in 19 patients. We use self made antibiotic cement rod to treat intramedullary infections. Compared with the beads it provides some limited mechanical support and can be preserved in the canal for a long time. We reviewed 19 infected patients who underwent removal of the nail excision of sinus tracks, debridement of the canal and insertion of the rods. No recurrent infection occurred in 18 cases, 11 cases achieved bony union, 6 cases achieved partial union. 1 patient had non-union and 1 patient

underwent amputation because of severe primary trauma and long term infection. The rod was removed between 35 and 123 days after implantation we conclude that the antibiotic cement rod could be a relatively effective, simple and inexpensive method of treating IM infectious after nailing.

10. Rodriguez Hugo, Ziran Bruce H, University San Jote del Rosario, Bogota, Colombia. St. Elizabeth Health centre, Youngstown, OH, ETATs – UNIS. Journal of clinical orthopaedics and related research ISSN 0009 – 921x CODEN CORTBR 2007, no 454, pp 270-274.

Study :

Temporary antibiotic cement covered gamma nail spacer for an infected non-union of the proximal femur.

We reported the case of an infected non union of proximal femur in an elderly patient. An impromptus use of a cephalomedullary nail coated with antibiotic – laden bone cement is described, followed by implantation with a revision type proximal femoral prosthesis.

MATERIALS AND METHODS

A prospective study of 20 patients of infected non-union of long bones of lower limb managed by antibiotic cement loaded nails and beads were done.

The period of study and follow up extends from November 2006 to November 2008 at Government Rajaji Hospital, Madurai.

We took infected non union of femur and Tibia in our study.

Inclusion Criteria:

1. Mild and moderate infection (according to Kulkarni's classification)
2. Shortening < 2 cm
3. With no deformity
4. Age group between 25 and 50 years

Exclusion criteria:

1. Severe infection
2. Shortening > 2 cm
3. With deformity
4. With poor skin and soft tissue condition.
5. Age < 25 years and > 50 years
6. Previous multiple failed procedures.

The basic surgical technique in my study as discussed earlier included the removal of infected nail , debridement and irrigation of medullary canal, preparation of Vancomycin loaded PMMA cemented nail and beads, insertion of antibiotic cemented nail into the medullary canal and implantation of beads at infected site.

Post operatively the beads were removed in most of the cases at 4 to 6 weeks interval; and 4 patients did not turn out for early beads removal and beads removal was done at 8 to 10 weeks interval. Bone grafting was done in 12 cases. We followed the cases for 12 to 24 months period. All cases united with an average time of 4.5 months. In 4 cases infection persisted in spite of union which required further procedures.

STATISTICAL ANALYSIS

Table : 1 Age Distribution

In our study the age group varied from 25 to 50 years with a mean of 35 years. Incidence was observed maximum between 25-40 years.

Age group	No. of cases	Percentage
25-35	10	50%
35-45	7	35%
45-50	3	15%

Table: 2 - Sex Distribution:

Among the 20 cases, males were predominant with a male to female ratio of 9: 1

Sex	No. of cases	Percentage
Male	17	85%
Female	3	15%

Table: 3- Site of Application

In our study series we took only infected non union of femur and tibia for analysis as they are more prone for infected non union.

We operated up to 16 cases of infected non-union of femur and 4 cases of Tibia.

Site	No. of cases	Percentage
Femur	16	80%
Tibia	4	20%

Table: 4. Severity of Infection:

We graded the severity of infection based upon Kulkarni's classification of infected non union.

Severity	Femur	Tibia	Percentage
Mild	11	1	60%
Moderate	5	3	40%

Table: 5 Side of infected non union

Of the 20 cases, the incidence of non union was more with femur than with tibia.

Of them the right side was more commonly involved.

Side	Side		Total
	Right	Left	
Femur	10	6	16
Tibia	3	1	4

Table-6 Number of Infected non union with previous procedures

	With implants	No implants
Femur	15	1
Tibia	4	0

Out of the 20 cases of infected non union, 19 cases occurred after previous procedures (18 cases after intramedullary nailing and 1 case after plating) and in 1 case of infected non-union of femur it occurred without any previous procedures.

Table - 7. Implant used for antibiotic cemented nailing:

	Implant		
	Femur IL Nail	Femur K Nail	Tibial IL nail
No. of cases	2	14	4

IL Nail – Interlocking nail K Nail - Kuntcher Nail

Both proximal and distal lockings was done in all cases in which interlocking nails were used.

Table - 8 Time of Union :

Time of Union	No. of cases	%
< 4 months	12	60%
4- 6 months	5	25%
> 6 months	3	15%

Table - 9. Patients required Bone grafting

	No. of cases	Percentage
Femur	10	62.5%
Tibia	2	50%

Table 10 : Complications

	No. of cases	Percentage
During Surgery		
Partial debonding of nail		
During insertion	2	10%
During removal	2	10%
Difficulty in beads removal	3	15%
After surgery		
Persistence of infection inspite of union	4	20%
Knee stiffness	3	15%
Shortening with deformity	1	5%
Lost follow up	1	5%

Table – 11 :

Second surgery for persistence of infection In spite of union:

	No. of cases
Antibiotic cemented nail removal	3
Sequestrectomy with nail removal	1

FOLLOW UP

Post operatively, the patient is kept on appropriate intravenous antibiotics based on the culture report for one week followed by oral antibiotics for 6 weeks. Follow up includes complete blood count, erythrocyte sedimentation rate, C – reactive protein for activity of infection, and x rays for signs of bony union.

The follow up period was 12-24 months.

Early hip and knee mobilisation exercise started to prevent post operative knee stiffness on the 1st post operative day.

If interlocking nails is used touchdown weight bearing is allowed in the 1st post operative day.

Quadriceps setting and straight leg raising exercise are begun before hospital discharge.

Weight bearing up to 40 lbs is allowed as callus formation occurs.

RESULTS AND ANALYSIS

- 85% of patients were male
- 50% of patients were between 25-35 year age group
- Right side was more common
- Femur infected non-union (80%) more reported than Tibia non-union cases
- Average time interval between primary procedure and antibiotic cemented nailing was 8 months
- Average time for bone union was 4 ½ months
- Overall percentage of complications was low compared to other methods
- 60% of patients required bone grafting.
- 95 % of patients went on for union.
- In 20 % of patients infection persisted in spite of union.

Complications :

During Surgery :

1. Partial debonding of nail during insertion – 2 cases
2. Partial debonding of nail during extraction – 2 cases
3. Difficulty in beads removal – 3 cases

After surgery

1. Knee stiffness – 3 cases
2. Persistence of infection in spite of bony union – 4 cases
3. Shortening with equinus deformity - 1 case
4. Lost follow up – 1 case

DISCUSSION

Antibiotic impregnated cement was first used to treat infection associated with Hip arthroplasty in the early 1970s. Antibiotic bead chains were subsequently introduced by Klemn in 1974 and have been widely used in established bony and soft tissue infections. Their proposed use as a prophylaxis against infection in introduction of the antibiotic bead pouch technique has reduced the incidence of infection in the management of open fractures.

The pathomechanics of infection after plating are different from those of infection after intramedullary nailing. Infection after plate osteosynthesis usually involves the fracture site and causes local sequestration. The infection is primarily extramedullary and the medullary cavity involvement is limited to the segment where the plate was. The intramedullary canal proximal and distal to the infection usually is not involved. Placement of antibiotic beads delivers, the antibiotics locally in a higher concentration and helps control the infection. Infection after intramedullary nail fixation usually involves the entire medullary canal. Infection spreads along the length of the nail and involves the entire length of the bone.

Infection is primarily intramedullary. This is the rationale of placement of intramedullary antibiotic bead chains.

Placement of an intramedullary antibiotic bead chain from the nail insertion site, after nail removal, poses some practical problems. Antibiotic bead chains are difficult to place into the medullary canal. They are incompatible with external fixators, as the chain cannot be introduced after pin placement. If placed before the pins, the chains cannot be removed easily. To overcome this, Klemn introduced the PMMA stick, which was fabricated by extruding antibiotic laden PMMA on a continuous monofilament wire. This was easy to introduce and remove. It could be passed around the fixator pins and if necessary could be exchanged as a minor procedure. The main disadvantage of the PMMA stick are the fact that it does not provide any stability to the fracture, requires external fixation and has not been evaluated in a prospective trail.

The antibiotic impregnated cement nail is an extension of the antibiotic PMMA stick used by Klemn. The antibiotic nail is not only used for the delivery of antibiotics but to provide some stability to the fracture. The antibiotic cement nail has several advantages over antibiotic beads in these situations. It provide more intimate

contact with the medullary canal and hence more elution of antibiotics to the endosteal surface. It can be inserted through the same portal of entry as the original nail. The nail transverses the entire medullary canal and enables a more effective delivery of the antibiotics. It is easy to remove and subsequent exchange nailing is technically easier than bead chain. The major advantage of this modality of treatment is that it is a single staged procedure and avoids systemic toxicity of antibiotics.

Based on our study and the report by Ohtsuka et al, we believe the antibiotic impregnated acrylic cement nail is an effective means of treating post intramedullary infection. Although our experience is limited to a small group of patients, future controlled prospective trails with large numbers of patients will help validate this technique.

CONCLUSION

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Control of infection and stability to promote union in infected non-union of femur and tibia has traditionally been provided by multiple surgical procedures which have proved to be not efficacious, with poor cooperation and compliance from patients. However the single staged procedure of antibiotic cemented nailing has achieved the goals of infection control and fracture union with good patient compliance. It avoids systemic toxicity of antibiotics, provides high concentration of local antibiotics and avoids multiple procedures with good patient compliance.

Hence we conclude that antibiotic cemented rods and beads could be a relatively effective, simple and inexpensive method of treating intramedullary infections.

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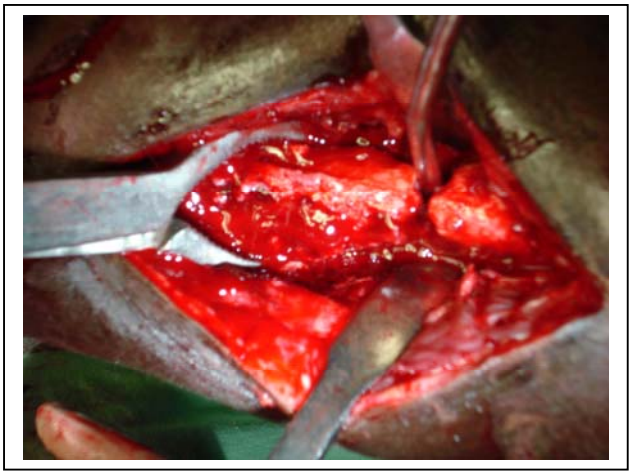
CONSTITUENTS OF ANTIBIOTIC CEMENTED NAIL AND BEADS

PREPARATION OF ANTIBIOTIC CEMENTED NAIL

PREPARED ANTIBIOTIC CEMENTED NAIL AND BEADS

DEBRIDEMENT OF MEDULLARY CANAL AND INFECTED NON UNION SITE

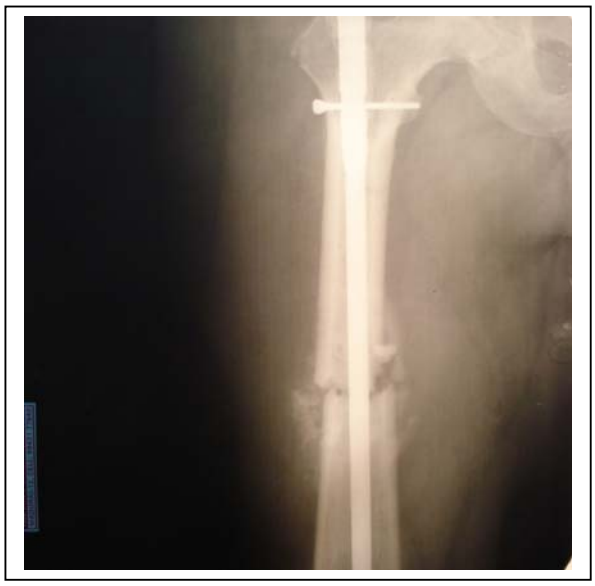


INSERTION OF ANTIBIOTIC CEMENTED NAIL IN MEDULLARY CANAL

BEADS REMOVAL AT 4 TO 6 WEEKS INTERVAL

CASE - 1

32 yr old female pt. with
5 months old infected
non-union right femur



4 months post operative

Full weight bearing at
4 months post op

No evidence of sinus with deep
infection – 4 months Post op

CASE – 2

26 yr old pt with 6 months old infected non union right femur

10 weeks of post operative

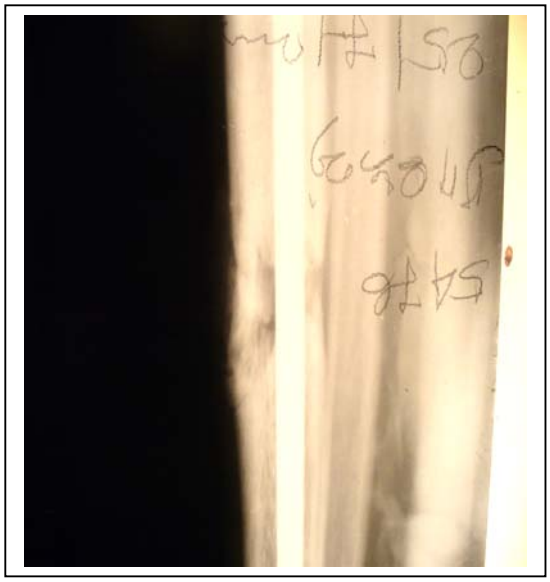
4 months post operative after beads removal

Partial weight bearing at 4 months

CASE – 3

29 yr old male pt. with 8 months old infected non union right tibia

3 months post operative



Weight bearing at 3 months

CASE - 4

31 yr old male patient with
11 months old infected non-union
right proximal femur

10 weeks post operative

4 months post operative

Full weight bearing of right lower Limb at 10weeks Post operative

Right knee with full range of motion

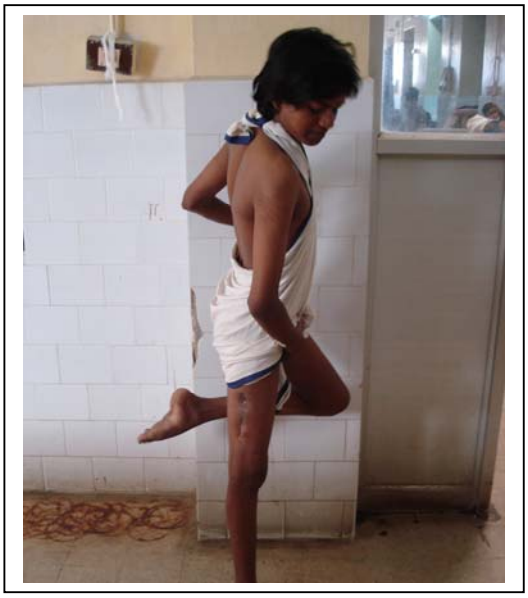
CASE – 5

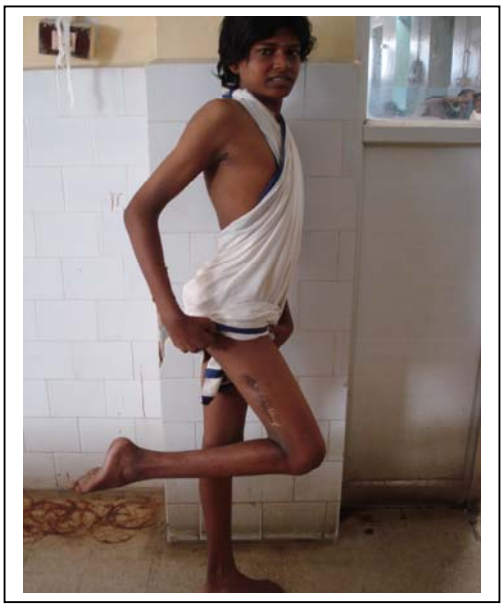
25 yr old pt with 18 months old infected non-union right femur

9 weeks post operative

Full weight bearing of right lower Limb at 9 weeks post operative

Right knee with full range of motion





COMPLICATIONS

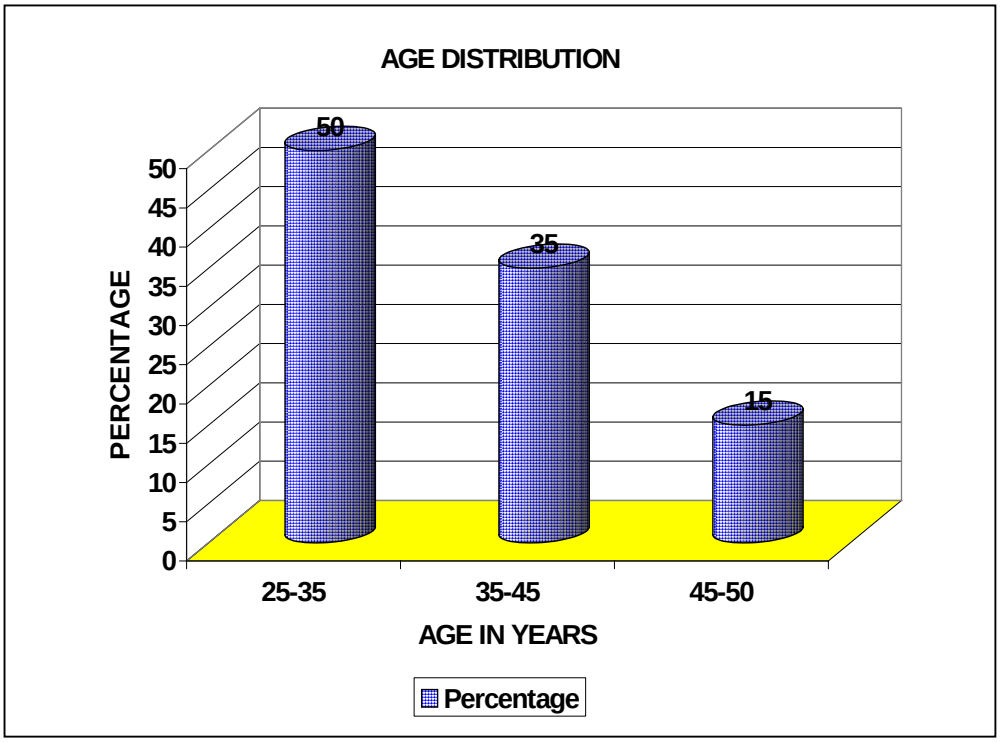
Persistance of infection inspite of bony union

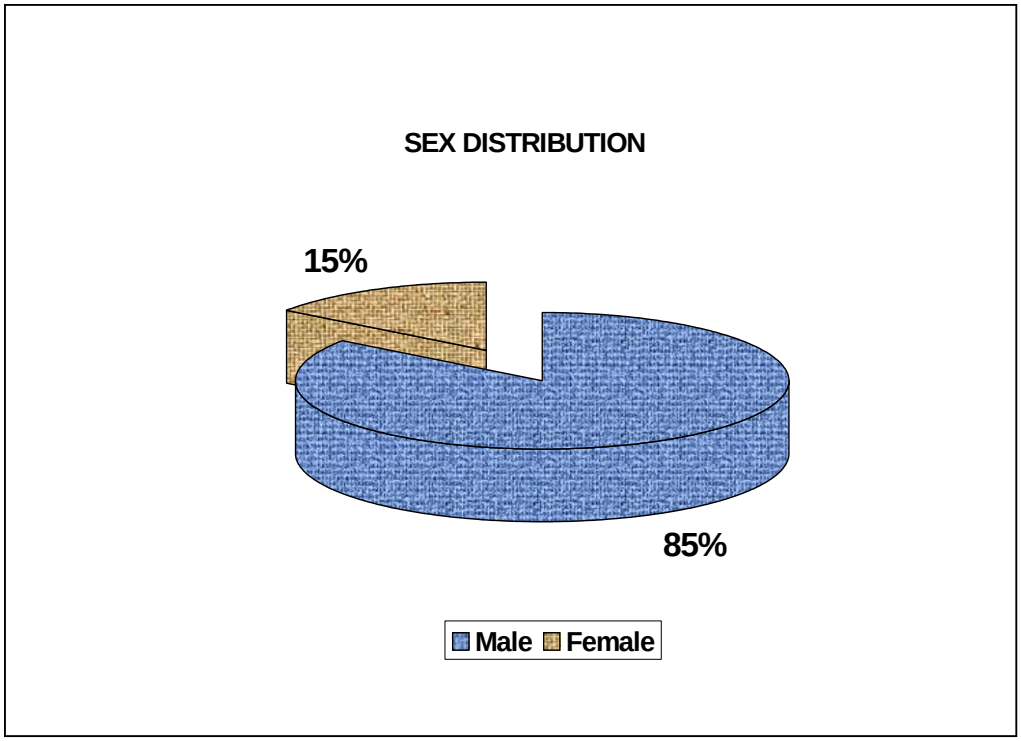
Shortening of limb with Equinus contracture

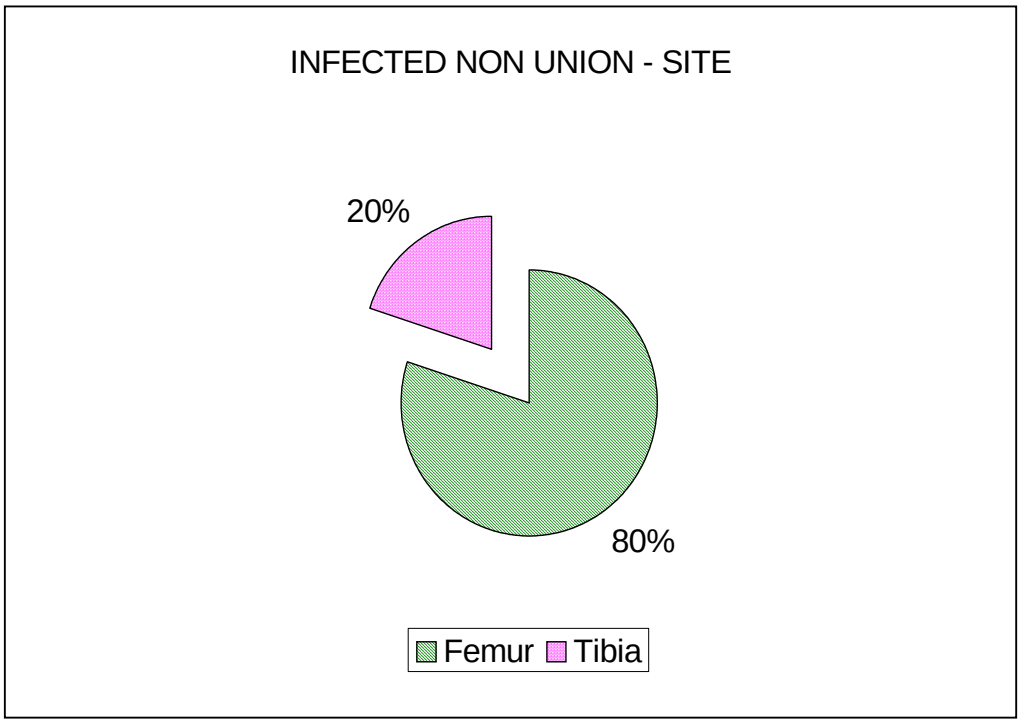
Partial debonding of nail during removal

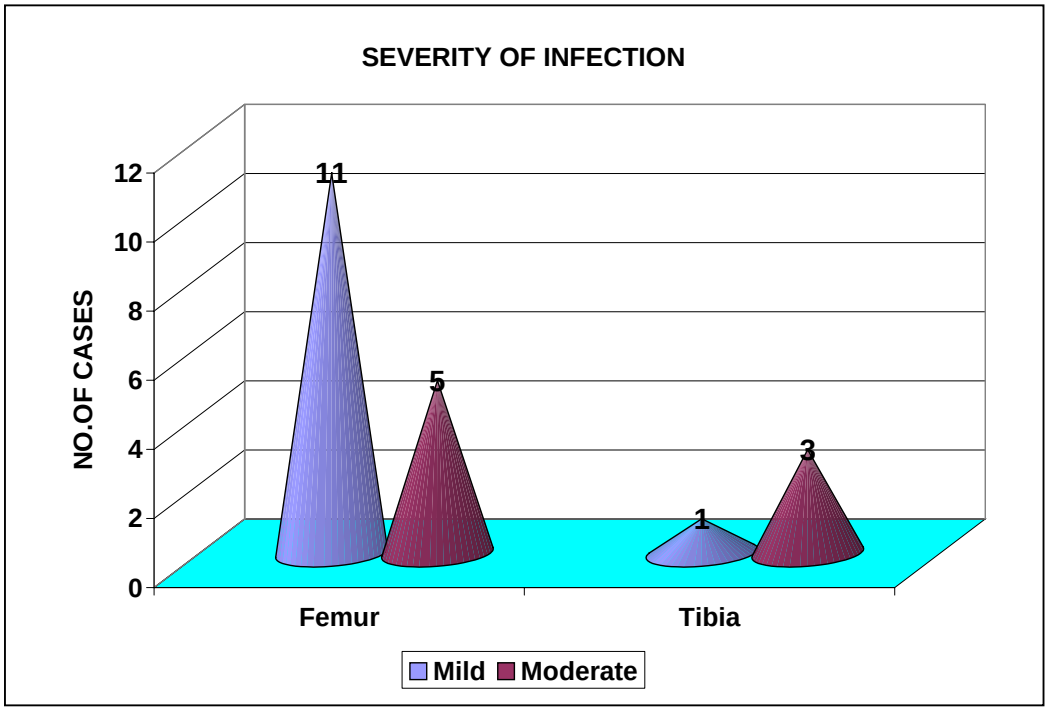
Knee stiffness

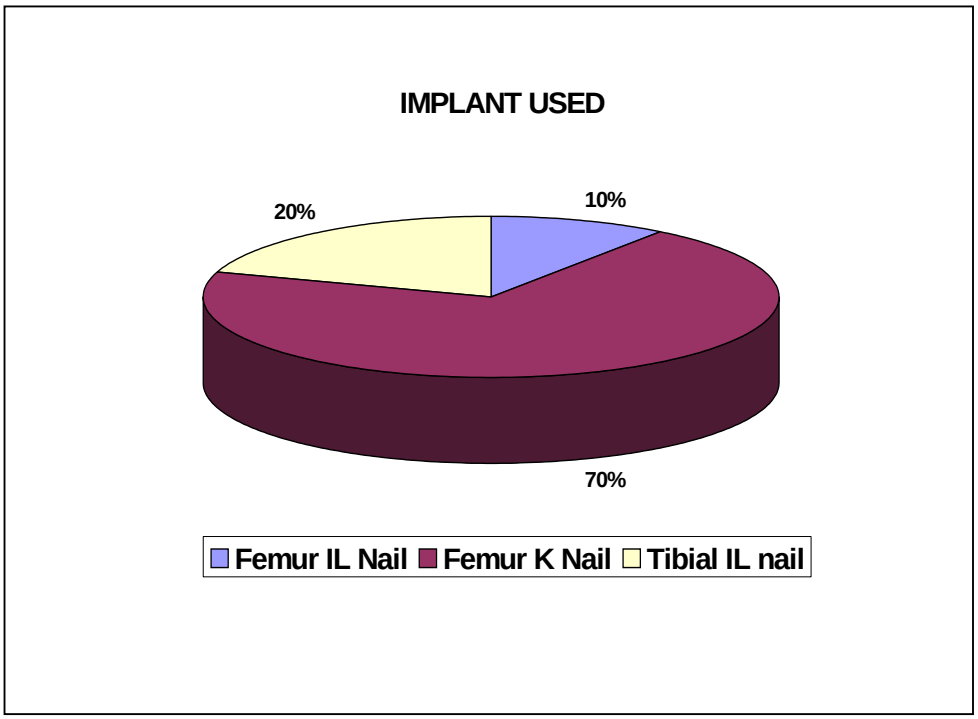
Difficulty in beads removal

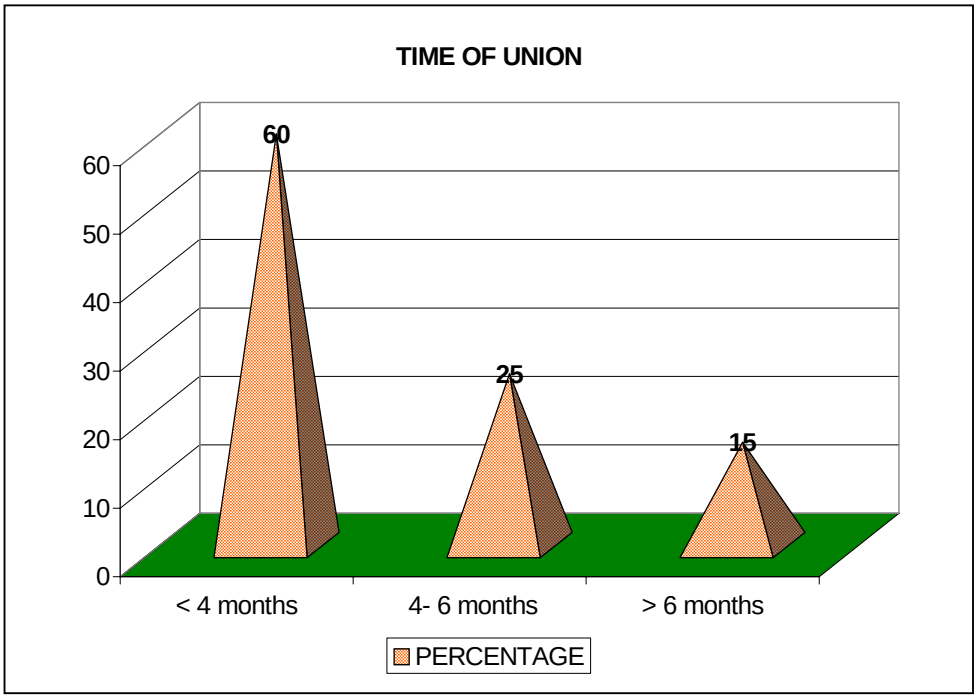

AGE DISTRIBUTION
PERCENTAGE
50
45
40
35
30
25
20
15
10
5
0
50
35
15
25-35
35-45
45-50
AGE IN YEARS
Percentage


SEX DISTRIBUTION
15%
85%
Male
Female


INFECTED NON UNION - SITE
20%
80%
Femur
Tibia


SEVERITY OF INFECTION
NO.OF CASES
0
2
4
6
8
10
12
11
5
1
3
Femur
Tibia
Mild
Moderate


IMPLANT USED
10%
20%
70%
Femur IL Nail
Femur K Nail
Tibial IL nail


TIME OF UNION
60
25
15
0
10
20
30
40
50
60
< 4 months
4- 6 months
> 6 months
PERCENTAGE

MASTER CHART

S.No.	Name	Age/Sex	IP No.	DOA	DOS	Site	Side	Severity of Infection	Interval between primary procedure and 2nd surgery (months)	Implant used	Bone grafting (Done)	Union time (months)	Complications during and after surgery
1.	Raja	43/M	37650	10-10-07	17-10-07	Femur	R	Mild	5	IL Nail	-	5 ½	Persistence of infection
2.	Mariappan	41/M	39236	6-12-07	12-12-07	Femur	L	Moderate	51/2	K Nail	Yes	7	-
3.	Sakthivel	32/M	52089	15-7-08	23-7-08	Femur	R	Mild	8	K Nail	Yes	4	Partial debonding of nail during removal
4.	Selvakumar	26/M	32340	9-9-07	18-9-07	Femur	R	Mild	7	K Nail	-	6	Knee stiffness
5.	Manokaran	33/M	41042	3-2-08	12-2-08	Femur	L	Mild	6	K Nail	Yes	3 ½	Difficulty in beads removal
6.	Panjavarnam	32/F	43250	16-4-08	25-4-08	Femur	R	Mild	5	K Nail	Yes	4	Persistence of infection
7.	Veerammal	42/F	51239	13-8-08	20-8-08	Femur	R	Mild	7	K Nail	Yes	4 ½	-
8.	Ilayaraja	25/M	30020	19-12-07	30-12-08	Femur	R	Moderate	18	K Nail	-	4	-
9.	Palanisamy	50/M	41974	26-6-08	4-7-08	Tibia	L	Mild	5	IL Nail	Yes	-	Lost follow up
10.	Mohan	29/M	47771	14-7-08	21-7-08	Tibia	R	Moderate	8	IL Nail	-	3 ½	-

11.	Paulpandi	36/M	39002	21-6-07	30-6-07	Femur	L	Mild	10	IL Nail	-	4	-
12.	Nagaraj	41/M	56719	16-8-08	20-8-08	Femur	R	Modertrate	8	K Nail	Yes	6	Partial debonding of nail during removal
13.	Rajavelan	31/M	31200	14-5-07	22-5-07	Femur	R	Mild	11	K nail	-	7	1.Limb shortening 2.Knee stiffness
14.	Arumugam	48/M	29209	27-1-07	3-2-07	Tibia	R	Moderate	9	IL Nail	Yes	3 ½	-
15.	Sugumaran	35/M	23794	3-2-07	12-2-07	Femur	L	Mild	7	K Nail	Yes	3 ½	1.Difficulty in beads removal 2.Knee stiffness
16.	Balakrishnan	32/M	27182	19-2-07	25-2-07	Femur	L	Mild	8 ½	K nail	Yes	4	Persistence of infection
17.	Samikannu	46/M	21264	25-4-07	6-5-07	Tibia	R	Moderate	12	IL Nail	-	4 ½	Partial debonding of nail during insertion
18.	Selvalakshmi	38/F	31992	30-6-07	9-7-07	Femur	R	Moderate	6	K Nail	Yes	3	-
19.	Udaiappan	28/M	36284	14-8-07	26-8-08	Femur	R	Mild	9	K Nail	Yes	4	Persistence of infection
20.	Kumaravel	39/M	43210	19-7-08	27-7-08	Femur	L	Mild	10	K Nail	-	8	1.Partial debonding of nail during insertion 2. Difficulty in beads removal