

# Management of Infected Non - Unions

John Mukhopadhyaya<sup>1</sup>

## Abstract

Infected nonunions are difficult problems to tackle. The treatment is often multistaged and involves high expenses and has major impact on both patient as well as surgeons. Understanding of the basics of infected non-union including etiopathology, diagnostic criteria and management algorithms is helpful in successfully managing this complication. This article provides a basic overview of infected nonunions along with new methods of management including Masquelet technique and techniques of managing bone gaps

**Keywords:** infected non-union, diagnosis, management

## Background

Infected non-unions of long bones is a combination of the two bugbears of fracture treatment.

1. Non-union
2. Osteomyelitis

Together they form a formidable challenge in management.

Treatment can be expensive and time consuming, may involve multiple procedures and significantly impacts the patient and his family physically, psychologically, financially and socially. In fact, failure of a fracture to heal has a negative impact on quality of life which is often greater than that of a patient with ischaemic heart disease or on renal dialysis. [1]

## Etiology [2,3]

The etiology of infected non-unions is often multifactorial. However there are predisposing factors, which include,

1. Open fractures

2. Internal fixation of closed fractures
3. Host factors
4. Surgeon factors

Risk of infection is higher in open fracture also dependant on the soft tissue injury and contamination. This is further increased if there is delay in treatment, inadequate debridement, poor soft tissue handling, inability to get adequate early soft tissue cover and inappropriate or inadequate stabilization.

The timing of internal fixation may also have a role to play in closed fractures especially in high energy trauma in regions where the soft tissue is susceptible such as the proximal tibia.

Host factors such as diabetes, immunosuppression smoking and poor general health may increase the risk of infection and non-unions after internal fixation of fractures.

Surgeon factors are possibly the most important and factors such as infrastructure, discipline in the operating rooms, surgical expertise, experience and appropriate use of antibiotics are all important factors.

## Diagnosis: [2,3]

The diagnosis is based on the medical history, clinical examination radiological features and laboratory examinations. In many situations the diagnosis is obvious clinically and radiologically. (Fig.1)

However this is not always so and a careful history and clinical examination is required to try and exclude features which may suggest possible infection. Any history of wound healing problems, pain and swelling in the post-operative period and prolonged use of antibiotics should be noted.

## Laboratory investigations:

Include ESR,CRP are often raised. However they may not always be high. However they are useful in monitoring progress of treatment. The white cell count (TLC) and neutrophil count may also be raised Bacterial cultures from draining sinuses are not reliable and multiple cultures as well as biopsies should be taken during surgical debridement. Radiological investigations Plain radiographs are often all that is

<sup>1</sup>Department of Orthopaedics and Joint Replacement, Paras HMRI Hospital, Patna, Bihar, India.

Address of Correspondence

Dr John Mukhopadhyaya

Department of Orthopaedics and Joint Replacement, Paras HMRI Hospital, Patna, Bihar, India.

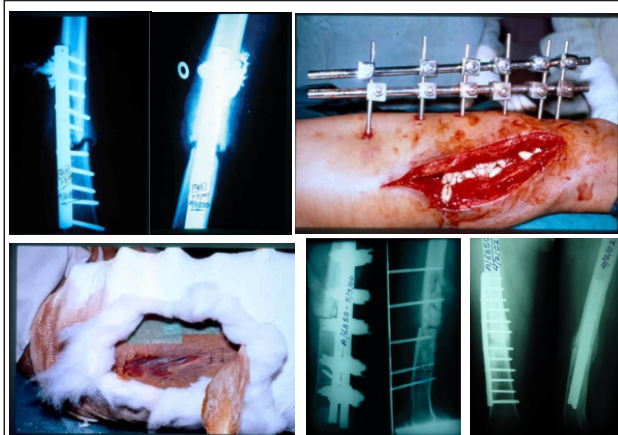
Email: mukhoj@gmail.com



**Fig.1.** Clinically and radiologically apparent infected non-union



**Fig2.** Non-union not apparent on plain radiographs needing CT



**Fig 3.** Infected non-union of femur treated in traditional two stage treatment.

necessary. They help in determining the type of non-union and the plan of management in terms of extent of bone excision that may be required.

CT scans would help in determining extent of bony involvement as well as delineating sequestrate. Occasionally CT scans may be useful in diagnosing a non-union that is not evident on Plain radiographs. ( Fig 2. )

MRI may be useful in determining the intramedullary extent of infection and differentiating bone and soft tissue infection.

Technetium 99-MDP bone scans have a very high sensitivity but low specificity in the diagnosis of infections. It may be useful in detecting patchy areas of bone involvement.

Indium -111 labeled scans have a higher specificity in detecting bone infections. PET scans are being used to more accurately localize the extent of bony and soft tissue involvement but is expensive available only at certain

centres.

#### Diagnostic criteria:

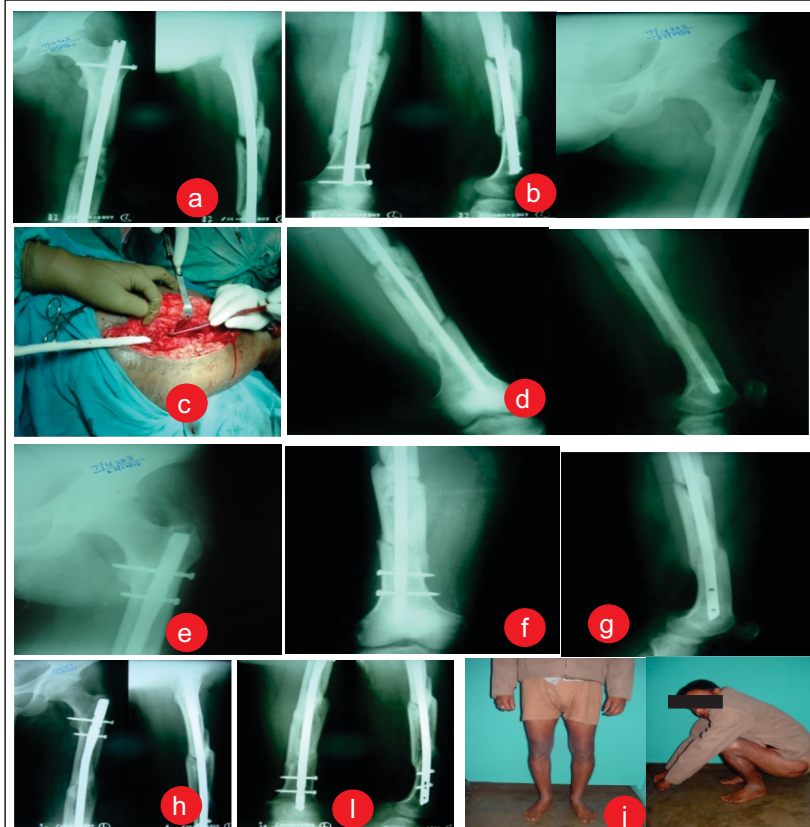
Based on the clinical, radiological and laboratory investigation a non-union can be said to be

definitely infected in the presence of

- draining sinuses
- frank pus
- positive cultures
- exposed bone devoid of periosteal coverage

An infection would be considered likely if there has been a history of

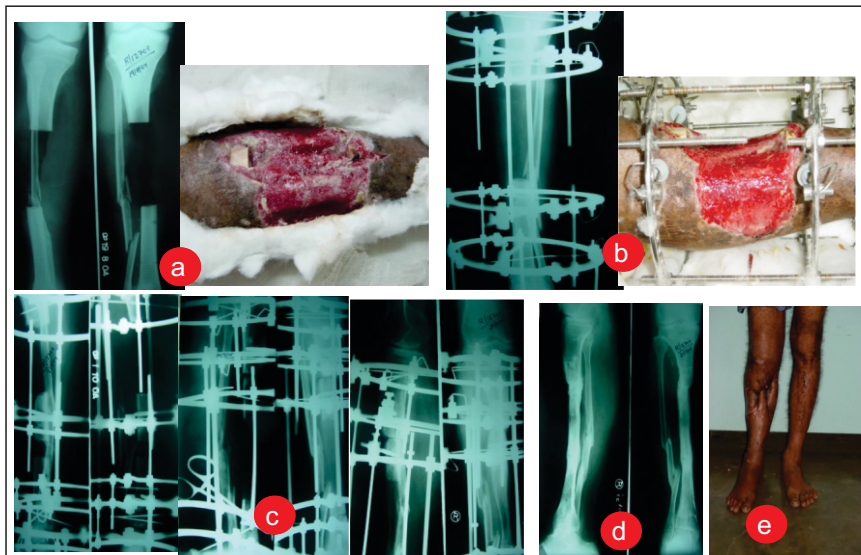
- wound healing problems after initial fixation
- history of multiple debridements required



**Fig 4:** Infected non-union treated with antibiotic coated nail a,b-28 year old male with infected non-union. c-debridement done. d-antibiotic impregnated cement coated IM rods inserted e,f,g- Removal of cemented K-nail & exchange nailing with AFN. h,i,j- One year post surgery with good union and function

- prolonged use of antibiotics
- presence of granulation tissue at surgery.

An infection will be considered unlikely if none of the above features are present. However even without any clinical evidence of infection it is possible to find evidence of infection at surgery. Hence it is important to warn patients of this possibility in every case of non-union where a previous surgery has



**Fig 5.** Infected non-union treated with through debridement leaving a bone gap soft tissue wound (a). Bone and soft tissue transport using Ilizarov ring fixator was done (b) with good regenerate formation (c). Good radiological and functional results were obtained at end of the procedure (d,e)

been required.

### Counseling:

The presence of infection may completely change the plan of management. Hence it is important to counsel adequately any patient undergoing surgery for a non-union especially where an implant has been used previously. Patients should be counseled about the length of treatment, the type of the treatment, the possible need for multiple surgeries, the expense involved and the potential complications

### Treatment

The goals of treatment in infected non-unions are

1. Eradicating infection
2. Achieving union
3. Restoring function. ( leg length, joint motion etc)

There were two schools of thought in the treatment to infected non-uniond

1. Union first
2. Infection elimination first

### Union first:

This was popular in the past with

moderate success. This should probably be reserved for cases where there is evidence of progression of union and the implants are secure with no loosening. Decortication and bone grafting may be added even in the presence of low grade infection.

Infection elimination first:

This is the method which is more popular and one we would use in most situations. Radical debridement would be the most important step in this strategy.

The management can be divided into 3 stages [4]

1. Early pathogen identification
2. Host alteration
3. Surgical strategies.

The surgical strategy in infected non-unions can again be divided into 4 steps.

1. Debridement
2. Stabilization
3. Dead space management and soft tissue cover
4. Achievement of bony union

### Debridement

Debridement needs to be thorough. It involves an approach similar to dealing with a low grade malignant tumour of

bone. It would usually involve removal of the previous implant, debridement of all tissue which is necrotic or marginal whether soft tissue or bone. One needs to take numerous cultures and biopsies from tissues from different layers. In cases of IM nails the medullary canal must be debrided with reaming and irrigation of the canal. Systemic intravenous antibiotics are administered intravenously and also delivered locally using PMMA bone cement, Calcium Sulphate on irrigation systems.

### Stabilization:

Once the debridement is adequately achieved the next step is stabilization of the fracture. This plays an important role in controlling infection.

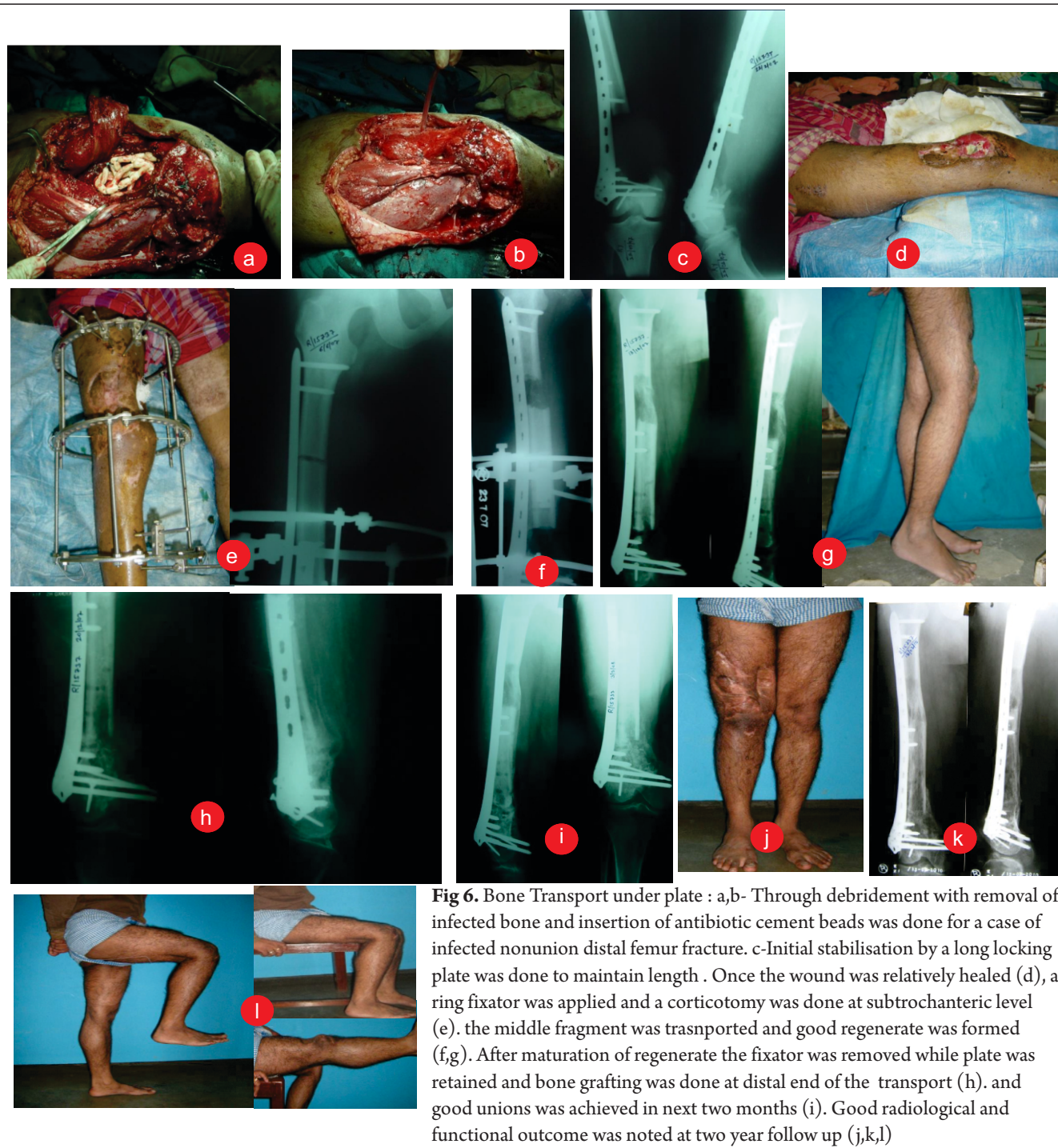
Conventionally the method of stabilization is an external fixator. Definitive fixation would be done after infection is controlled. (Fig 3.)

Other options for stabilization may be an intramedullary nails and plates. Intramedullary nails are suitable for diaphyseal fractures and antibiotic coated nails can be used after thorough debridement especially for mid diaphyseal fractures of the femur or tibia. (Fig 4.) [5,6]. At times antibiotic impregnated nails can be utilised as final fixation devices, especially if the bone gap is less than 4 cms [7]

With the advent of locked plates such as the LCP plates can be used in the (internal fixator) mode for stabilization of fractures. This is specially suited for metaphyseal regions where the nail may not be able to provide adequate stability.

Wound and dead space management:

As in open fractures the need for early soft tissue cover when required is now well accepted. Some form of wound temporization using Negative Pressure Wound Therapy or the antibiotic bead pouch may be required sometimes but where needed an early flap cover should be decided on. The use of Negative Pressure Wound Therapy has made a



**Fig 6.** Bone Transport under plate : a,b- Through debridement with removal of infected bone and insertion of antibiotic cement beads was done for a case of infected nonunion distal femur fracture. c-Initial stabilisation by a long locking plate was done to maintain length . Once the wound was relatively healed (d), a ring fixator was applied and a corticotomy was done at subtrochanteric level (e). the middle fragment was transported and good regenerate was formed (f,g). After maturation of regenerate the fixator was removed while plate was retained and bone grafting was done at distal end of the transport (h). and good unions was achieved in next two months (i). Good radiological and functional outcome was noted at two year follow up (j,k,l)

significant difference in the management of these wounds and has made it possible to improve local wound conditions , and also reduce the size of flap cover required [8].

#### **Achieving bony union:**

Traditionally after achieving control of infection at a second stage bone healing is attempted. A variety of methods Where there is no bone or soft tissue

defect stable internal fixation and bone grafting may be performed. The implant could be an intramedullary nail or plate depending on the site and surgeon's preference. A definitive external fixator may be an option.

#### **Bone gaps :**

Where there is a bone gap or a defect there is a range of options depending on the size and site of the defect. These

include acute shortening, in situ reconstructions ,free tissue transfers and bone transport techniques. The Masquelet technique is another method which has gained popularity in the treatment of large bone defects [9]. **Acute shortening:** Acute shortening at of the bone allows direct fixation with coaptation of bone ends. This technique may be used defects of up to 3-4cms. Larger defects, when acutely



**Fig 7.** The Masquelet technique for radius infected non union. a- infected nonunion of radius in a young man. b- debridement was done and the bone gap was filled with cement block (b). c. after 6 weeks the cement block was removed and the membrane tube formed was filled with bone graft with plate fixation across the gap. d- the fracture consolidated in next three months with good functional outcome (e,f,g,h)

shortened are accompanied by venous stasis and/or sluggish inflow as well as skin problems. Appropriate use of this technique can decrease the need for plastic surgical cover. Limb length equalization may be required later for lower limb non-unions.

#### **In situ reconstruction :**

Smaller defects can be reconstructed with fixation and cortico-cancellous bone grafting. Antibiotics can be mixed with the bone graft. This is usually done in two stages after elimination of infection. A corticocancellous iliac strut graft or even a fibular strut graft may be used. However there is a risk of failure which makes this method less predictable than some of the other methods.

More recently the Masquelet technique has become very popular for reconstruction of large defects using the concept of induced membrane osteogenesis. This will be discussed

briefly later.

#### **Free tissue transfer:**

Free vascularised bone grafts, commonly from fibula or iliac crest can be used for reconstruction. A two stage strategy is necessary to control infection before free tissue transfer to provide biological environment for healing of bone and soft tissue. Non vascularised fibula has also been shown to effective in achieving good success rates [10] Composite bone grafts with skin and soft tissue along with bone may be used for combined bone and soft tissue defects.

#### **The Ilizarov technique: [2,11] (Fig. 5)**

This technique may still be the gold standard in the treatment of large bone defects especially in the presence of infection. The advantage of this method is that the various problems of infection, deformity, limb length and

non-union can be addressed.

Bone, when divided using a low-energy osteotomy and subjected to controlled distraction is capable of regeneration. Therefore, surgically excised bone can be regenerated, in another area of the same bone, to make up length and to close bone defects. In addition, the limb experiences a significant increase in blood supply. Ilizarov used this method exclusively, without the need for two-stage surgery, and stated that 'infection burns in the fire of the regenerate'. However this probably only applies to micro sequester and obvious dead fragments of bone and soft tissue will need to be excised to eradicate infection.

We usually do a thorough debridement with stabilization with the ring fixator. We usually delay the corticotomy for a few days especially in infections after intramedullary nailing.

When the defect size is small acute shortening with docking of the non-

union site may be done. Lengthening is done through a metaphyseal corticotomy away from the non-union site.

For larger defects bone transport will be required. The bone is maintained at its original length with a gap at the fracture site. A corticotomy is done at the metaphysis and the middle segmented transported at a rate of 1 mm per day. The gap is gradually reduced with bone (regenerate) forming at the distraction site. When the gap is closed completely the non-union ends are docked. This usually involves freshening of the ends and bone grafting. Some surgeons feel that bone grafting can be avoided by compression distraction techniques at the fracture site. There is simultaneous transport of skin and soft tissue and sometimes it may be possible to avoid major plastic surgical reconstructions. (Fig 5.)

However the quality of skin and soft tissue may be thin and liable to breakdown. Local or free flaps may be required to ensure healthy robust cover. Unilateral fixators such as the Orthofix LRS may be more suitable for the femur where the Ilizarov rings may not be well tolerated by patients.

#### **Disadvantages :**

Conventional methods bone transport have certain disadvantages. These include prolonged fixator times, pintrack problems, problems with docking site, skin and soft tissue undermining, patient compliance and also refractures after removal of fixators. Various methods have been used to avoid these problems including plating after transport and transport over nails. We have also used transport under locking plates as a method in some difficult gap non-unions [12]. This offers the advantages of excellent stability, reduction of fixator times and reduced risks of refractures. (Fig 6.)

#### **Masquelet Technique : [9](Fig. 7)**

The Masquelet technique has become a popular technique in the treatment of open fractures with bone loss and in infected non-unions with bone gaps.

The basic principle of the management can be divided in two stages.

The first stage involves thorough debridement, excision of necrotic bone end, stabilization of the fracture and then filling the bone gap with antibiotic impregnated bone cement.

The cement spacer then maintains the space for reconstruction, provides additional stability, provides high concentration of local antibiotics and also induces a reactive membrane.

At a second stage about 4-6 weeks later a massive cancellous bone grafting is performed to fill the defect.

The membrane avoids the resorption of bone graft, promotes revascularization of the graft and also secretes various factors such as TGF, VEGF and BMPs which promote healing. Autologous bone graft may be mixed with bone substitutes, and some also recommend the addition of BMPs which we have not used as yet. Reamer Irrigation Aspiration has become a popular method of obtaining massive autologous bone graft which may be required.

Instead of pure cancellous bone graft a combination of a strut iliac crest or fibular graft along with autologous cancellous bone graft may be used. (Fig 7c)

#### **Rehabilitation**

This forms an equally important part of treatment along with dealing with the infected non-union. Rehabilitation involves not just physical rehabilitation but, social and psychological rehabilitation as well. This needs to hand in hand with the surgical management and hence having a multi-disciplinary team would be ideal.

#### **Summary :**

With increasing trauma and the increase in internal fixation of fractures it is little surprise that we have to deal with a large number of infected non-unions. Road traffic accidents in India are rising at an alarming rate [13]. More severely injured patients also means patients being operated on when their physiological conditions are not ideal leading to increased susceptibility to infections. Add to that the inappropriate use of antibiotics which result in the initial signs of infection being masked and infection presenting late when it is well established.

We also see patients in whom even after infection is evident, antibiotics are continued for long periods without debridement and attempts to identify the infecting organism. This over a period of time leads to formation of multiple discharging sinuses, fibrous tissue formation and development of organisms resistant to multiple antibiotics.

Treating these infected non-unions can be a difficult and challenging task. We need to also look at the host factors, correct anaemia and hypoproteinaemia which are very common. Blood sugar needs to be well controlled in diabetics and the patient should be off antibiotics for a period of two weeks before surgery to be able to get a reasonable culture report.

The debridement as mentioned earlier need to be radical, almost oncologic to be able to get rid of not just all necrotic bone but also necrotic soft tissue, sinus tracts etc. After adequate debridement the fracture needs to be stabilized. The traditional method is the external fixator but the locking plates have given us the option of using the locked plates in situations where the external fixators are inconvenient or do not provide good stability. The use of antibiotic loaded bone cement and other carriers

has it made it possible to have high local concentration of antibiotics without systemic side effects.

Bone grafting is usually added once the infection is controlled and may be mixed with antibiotics.

Even after the fracture has healed, an appropriate rehabilitation protocol is

required for the best functional results.

### Conclusions:

Infected non-unions are a challenging problem for the orthopaedic surgeon.

Care has to be taken to exclude infection when dealing with non-unions and adequate counseling is

essential. Treatment can be prolonged and frustrating and requires patience and understanding. Many new techniques and developments have improved the prognosis but further challenges also lie ahead.

## References

1. Brinker MR, Hanus BD, Sen M, O'Connor DP. The devastating effects of tibial nonunion on health-related quality of life. *J Bone Joint Surg Am.* 2013 Dec 18;95(24):2170-6.
2. Struijs PA, Poolman RW, Bhandari M. Infected nonunion of the long bones. *J Orthop Trauma.* 2007 Aug;21(7):507-11.
3. Chaudhary MM. Infected nonunion of tibia. *Indian J Orthop.* 2017 May-Jun;51(3):256-268.
4. Tetsworth K, Cierny G 3rd. Osteomyelitis debridement techniques. *Clin Orthop Relat Res.* 1999 Mar;(360):87-96.
5. Shyam AK, Sancheti PK, Patel SK, Rocha S, Pradhan C, Patil A. Use of antibiotic cement-impregnated intramedullary nail in treatment of infected non-union of long bones. *Indian J Orthop.* 2009 Oct;43(4):396-402.
6. Bhatia C, Tiwari AK, Sharma SB, Thalanki S, Rai A. Role of Antibiotic Cement Coated Nailing in Infected Nonunion of Tibia. *Malays Orthop J.* 2017 Mar;11(1):6-11.
7. Pradhan C, Patil A, Puram C, Attarde D, Sancheti P, Shyam A. Can antibiotic impregnated cement nail achieve both infection control and bony union in infected diaphyseal femoral non-unions? *Injury.* 2017 Aug;48 Suppl 2:S66-S71.
8. Putnis S, Khan WS, Wong JM. Negative pressure wound therapy - a review of its uses in orthopaedic trauma. *Open Orthop J.* 2014 Jun 27;8:142-7.
9. Giannoudis PV, Faour O, Goff T, Kanakaris N, Dimitriou R. Masquelet technique for the treatment of bone defects: tips-tricks and future directions. *Injury.* 2011 Jun;42(6):591-8.
10. Patwardhan S, Shyam AK, Mody RA, Sancheti PK, Mehta R, Agrawat H. Reconstruction of bone defects after osteomyelitis with nonvascularized fibular graft: a retrospective study in twenty-six children. *J Bone Joint Surg Am.* 2013 May 1;95(9):e56, S1.
11. Yin P, Ji Q, Li T, Li J, Li Z, Liu J, Wang G, Wang S, Zhang L, Mao Z, Tang P. A Systematic Review and Meta-Analysis of Ilizarov Methods in the Treatment of Infected Nonunion of Tibia and Femur. *PLoS One.* 2015 Nov 3;10(11):e0141973
12. Mukhopadhyaya J, Raj M. Distraction osteogenesis using combined locking plate and Ilizarov fixator in the treatment of bone defect: A report of 2 cases. *Indian J Orthop.* 2017 Mar-Apr;51(2):222-228.
13. Dhillon MS, Rajasekharan S, Sancheti P. Status of road safety and injury burden: India. *J Orthop Trauma.* 2014;28 Suppl 1:S43-4.

**Conflict of Interest:** NIL  
**Source of Support:** NIL

### How to Cite this Article

Mukhopadhyaya J. Management of Infected Non-unions. *Journal of Clinical Orthopaedics* July-Dec 2017; 2(2):25-31