Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/jcot

Case Report

Induced membrane formation in a case of infected gap nonunion of radius: Case report

Shameem Ahmad MS (Ortho)^{a,*}, Mukesh Kalra MS (Ortho)^b,
Mariappan Selvamari^c

^a Senior Resident, Department of Orthopaedics, PGIMER, Dr RML Hospital, India

^b Professor and Head of Unit, Department of Orthopaedics, Lady Harding and Associated Hospitals, India

^c Post Graduate Student, Department of Orthopaedics, PGIMER, Dr RML Hospital, India

ARTICLE INFO

Article history:

Received 10 September 2013

Accepted 12 September 2013

Available online 8 October 2013

Keywords:

Infected gap nonunion

Bone cement

Cancellous bone graft

Induced membrane formation

ABSTRACT

Infected gap nonunion in long bone fractures is a common problem seen in our setup after compound injuries. Treatment options are limited such as Ilizarov ring fixation with bone transport, vascularised bone graft etc. These techniques require expertise and are associated with their own morbidity and complications. A novel technique called as induced membrane formation, is used to bridge a gap nonunion of more than 5 cm using bone cement as a spacer in first stage and autologous cancellous bone graft to fill the gap once infection is healed along with a bridging plate in second stage.

Copyright © 2013, Delhi Orthopaedic Association. All rights reserved.

1. Introduction

The reconstruction of long bone diaphyseal defect is a challenging task. It is difficult to reconstruct the gap whatever the aetiology is or whichever long bone it is. The commonly available method is Ilizarov bone transport which is easier in lower limb as compared to lower limb or vascularised bone free transfer. Bone grafts are used along with these methods, but the bone graft is vulnerable to resorption¹ if the defect is more than 4–5 cm and therefore the nonunion remains.

In a case of infected gap nonunion, the goal of treatment is to control the infection and bridge the gap nonunion. In our case we used cement as a spacer along with antibiotic cover to control the infection in the first stage and in second stage, non-vascularised cancellous bone graft with a locking plate

was applied. This concept is known as "induced membrane formation"^{1–3} at the gap nonunion.

2. Case history

A 35-year-old male patient presented to us, 2 months after an ORIF done on both bone forearm fracture of left upper limb. He sustained the fracture in an RTA and was operated 4 days after the trauma in a private hospital elsewhere. Henry's approach was used for fixation of radius, as it was a mid-shaft fracture and LCDCP was used for fixation. According to the post-operative radiographs available the fractures were fixed not keeping ulna variance in the acceptable limit and DRUJ got subluxated. According to the patient, 15 days after the

* Corresponding author. H NO 3056, Shahganj, Ajmeri Gate, Delhi 110006, India. Tel.: +91 9811899657.

E-mail addresses: drshameem1982@yahoo.co.in, chaltechalte9211@gmail.com (S. Ahmad).

0976-5662/\$ – see front matter Copyright © 2013, Delhi Orthopaedic Association. All rights reserved.

<http://dx.doi.org/10.1016/j.jcot.2013.09.006>

surgery, there was pus discharge from the operative site of radius. For this the treating surgeon kept him on oral antibiotics for one and a half month but it didn't help and at the end of 2 months the implant failed. Plate got pulled out from the radius and patient presented to us. So the patient was posted for debridement and implant removal. While the implant removal was being done, it was found that the shaft of the radius had become infected and necrotic and had to be debrided. So a gap of around 5 cm was created at the fracture site. During the whole process, ulna was not involved, so not touched.

At this stage a spacer made up of antibiotic-impregnated bone cement was shaped and sized according to the radius and was integrated at the gap nonunion site. JESS fixator was applied and wound was closed as usual. Post op. iv antibiotics were given for 2 weeks and oral antibiotics were continued for another 1 month. At the end of 4 weeks after putting the bone cement, JESS fixator was removed. And slab was given for another 2 weeks to let the soft tissue heal.

After completion of 6 weeks the wound had healed and no discharge or any signs of inflammation were seen. Within next week, the second stage was planned. The spacer site was exposed through the same incision and the spacer with its surrounding membrane was approached. This membrane which has formed around the bone and the spacer was sharply incised just like a periosteal sleeve. Bone cement came out and membrane lined cavity was seen at the gap union site. No pus or any kind of dead or necrotic tissue was seen.

Bone graft was taken from the iliac crest and was morcelised and was filled inside the membrane lined cavity. The membrane was sutured over which a 10-holes locking compression plate in a bridging and locking mode was applied and the wound was closed. An above elbow plaster slab was given and iv-antibiotics were given. At the end of two weeks the wound was healthy and sutures were removed. Post-op immobilisation was continued for another 4 more weeks. After which, active mobilisation of the limb was started.

At the end of 5 months patient was reviewed. Functionally and radiographically the graft had incorporated into the bone and all the gap had been restored at the nonunion site. Patient has complete flexion and extension at the elbow joint. Whereas supination is 5° less and pronation is 7° less as compared to normal side, which is most likely because of subluxated DRUJ, which was not taken care-off in primary surgery.

Sequential radiographs of the patient since the time of first surgery till 5 months after the procedure (Figs. 1–6).

3. Discussion

The management of segmental long bone defects is a challenge. Techniques available are fraught with various difficulties and their associated complications. Smaller defects can be treated with autologous bone graft and rigid fixation but not when the defect size exceeds 5 cm. Because beyond 4–5 cm defect the bone graft gets resorbed and the defect

Fig. 1 – Initial radiograph, 8 weeks after primary fixation showing implant failure. The plate in radius has been pulled out and radius is angulated at the fracture site.

Fig. 2 – Radiograph showing bone cement as a spacer in mid-shaft of radius along with JESS fixator. Note the ulna is intact with its implant in place.

Fig. 3 – Radiograph after 2 weeks of fixator removal and bone spacer in place.

remains though cancellous bone graft possess higher osteoconductive and osteoinductive potential.^{1,4,5}

Larger defects can be treated by vascularised bone transfer or distraction histiogenesis. The transfer of vascularised bone can be done using ribs, fibula or iliac crest but it is limited by pedicle length and expertise required for microsurgical anastomoses.⁶ Donor site morbidity is another known complication.

Distraction histiogenesis is one of the most commonly used techniques to bridge the bone gap. This technique requires specialised training and equipments and are associated with complications like pin tract infection and nonunion.

The technique of "induced membrane formation and bone grafting" was first described by Masquelet of France in 1986.¹ He has used this technique to bridge the diaphyseal defects of upto 25 cm in length. In this technique methyl methacrylate cement spacer induces formation of a membrane thus creating a pocket for subsequent bone grafting. In other words the closed space created by removal of cement spacer acts as a biological chamber. Pelissier et al determined that these membranes have a rich capillary network and secretes growth factors (VEGF and TGF-beta 1) and osteoinductive factor

Fig. 4 – Photograph showing the membrane induced after removal of bone cement.

Fig. 5 – Radiograph after 2 months of plating and bone grafting.

Fig. 6 – 5 months after bone grafting.

(BMP-2) in high concentrations as early as 2 weeks.^{7,8,9} The inner part of the membrane which is facing the cement is a synovium like epithelium and outer part is made of fibroblast, myofibroblast and collagen. Last but not the least, according to Masquelet, membrane extracts were shown to stimulate bone marrow cell proliferation and differentiation to osteoblastic lineage.¹

The membrane prevents resorption of the cancellous bone graft while it is known that a large amount of cancellous bone placed in a vascular environment is partially or completely resorbed. The membrane promotes vascularisation and corticalisation of the cancellous bone.^{6,7} It is considered as an *in situ* delivery system for osteoinductive factors.⁹

Another important purpose which the spacer serves is that the block placed between the gap helps the soft tissue to not collapse at the fracture site⁸ and the space is maintained for subsequent bone grafting.¹⁰

In this case report the presence of induced membrane was documented by visual inspection of the fracture gap after removal of cement spacer. In our patient infection was present in the region of segmental bone loss. So the antibiotic cement targeted the contaminating pathogen. This is an extension of the concept of antibiotic-impregnated beads in the management of dead space in segmental bone defects and the use of an antibiotic in this fashion has previously been described for septic nonunion and chronic osteomyelitis.

In our patient the DRUJ is subluxated though ulna has united. The surgeon who did the primary fixation didn't take care of ulnar variance at the outset. We did not touch ulna at this stage because of chances of spread of infection to this bone. Now when both the bones of forearm are united and the patient is carrying out his daily activities with some amount of discomfort and pain at DRUJ, we will plan an ulnar shortening procedure at a later stage, when the patient is ready.

To conclude, successful reconstruction of extensive bone defect is possible with induced membrane formation. The two-step surgical procedure is an advantage in case of primary infection which requires debridement. This technique holds true to the concept that the genesis of life takes place in a veiled environment be it a womb of a mother or a seed in the soil which germinates to produce a whole crop.

Conflicts of interest

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

REFERENCES

1. Masquelet AC, Obert L. Induced membrane technique for bone defects in hand and wrist. *Chir Main*. 2010;29(suppl 1):S221–S224.
2. Masquelet AC, Begue T. The concept of induced membrane for reconstruction of long bone defects. *Orthop Clin North Am*. 2010;41:27–37.
3. Klauke K, Knothe U, Rampoldi E, Masquelet AC, Perren SM. Biological implementation of “*in situ*” induced autologous foreign body membranes in consolidation of massive cancellous bone grafts. Orthopaedic proceedings. *J Bone Joint Surg*. 1993;79B(suppl 3):236.
4. Romana MC, Masquelet AC. Vascularised periosteum associated with cancellous bone graft: an experimental study. *Plast Reconstr Surg*. 1990;85:587–592.
5. Masquelet AC, Fitoussi F, Begue T, Muller GP. Reconstruction des os longs par membrane induite et autogreffe spongieuse. *Ann Chir Plast Esthet*. 2000;45:346–353.
6. Woon CY, Chong KW, Wong MK. Induced membranes – a staged technique of bone grafting for segmental bone loss: a report of two cases and a literature review. *J Bone Joint Surg Am*. 2010;92:196–201.
7. Pelissier P, Masquelet AC, Bareille R, Mathoulin-Pelissier S, Amedee J. Induced membranes secretes growth factors including vascular and osteoinductive factors and could stimulate bone regeneration. *J Orthop Res*. 2004;22:73–79.
8. Pelissier P, Martin D, Baudet J, Lepreux S, Masquelet AC. Behaviour of cancellous bone graft placed in induced membranes. *Br J Plast Surg*. 2002;55:596–598.
9. Spinella-Jaegle S, Roman S, Faucheu C, et al. Opposite effects of BMP-2 and TGF beta-1 on osteoblast differentiation. *Bone*. 1998;29:323–330.
10. Chong KW, Woon CY, Wong MK. Induced membranes – a staged technique of bone grafting for segmental bone loss: surgical technique. *J Bone Joint Surg Am*. 2011;93(suppl 1):85–91.