Original Research Paper

Treatment of Post-traumatic Bone Defects with Infection in Long Bones

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Abstract: Masquelet technique, which is the use of a temporary cement spacer followed by staged bone grafting, is a recent treatment strategy to manage an infected nonunion with bone defect. This paper describes a series of 20 patients treated with this technique of staged bone grafting following placement of an antibiotic spacer to successfully manage infection as well as bone defects in long bones. The injured limbs were stabilized and aligned at the time of initial spacer placement. In our series, osseous consolidation was successfully achieved in all cases. This technique gives promising result in the management of post-traumatic bone defects associated with infection.

Key Words: Bone reconstruction, Bone defect, Induced membrane, Open fracture, Bone infection, and Post-traumatic infected non union

Introduction:

The tibia is one of the most commonly fractured long bones [1]. Open fractures are more common in the tibia than in any other major long bone [1]. Incidences of complex open injuries of the limbs are on the rise owing to the increased number of high energy vehicular accidents in recent times, which subsequently giving rise to more cases of infected non-unions. High-energy fractures may be associated with bone loss, compartment syndrome, neurovascular injury and infection. Segmental bone defects resulting from traumatic injuries are complicated problems with significant long-term morbidity. Historically, due to the difficulty in managing segmental long bone defects, amputation was the preferred treatment. Various researchers over the years have used many different approaches to deal with these complex problems. But, it has not been possible to address all the problems mentioned above by using any single technique. In 1986, A.C. Masquelet conceived and developed an original reconstruction technique for large diaphyseal bone defects, based on the notion of the induced membrane [4–6]. The principle of Masquelet technique involves provoking a reaction to a foreign body by placing a cement spacer in the bone defect. The membrane induced by this foreign body is in fact a biological chamber which prevents graft resorption by providing vascularization and growth factors, as shown by various clinical, experimental and basic studies [4–13]

The present study was performed on patients of bone defect in long bones alongwith infection treated by the Masquelet technique. The aim of the present study was to analyze the results of this study and compare them with those in the literature.

Patients and Methods:

This study includes 20 post-traumatic long bone defects with infection who were treated in Department of Orthopaedics, Govt. Medical College, Patiala between April,2016 to July,2017 by Masquelet technique . The present study included 18 men and 2 women (mean age 32.5 years). In all cases, the initial trauma was an open fracture. Tibia was involved in maximum number of cases (55%), followed by Femur bone in 30% and Humerus in 15% cases. The mean delay between the accident and treatment of bone defects was 2.5 months. In 85% of the cases, infection was present. Bone defects were larger than 5 cm in 60% of the cases. The patients were evaluated for injury type, location, soft tissue condition, length of bone defect, antibiotic used, and duration of cementation. Moreover, the type of fixation, presence of infection, and current state of all patients was recorded.

Surgical Technique:

Masquelet technique is a two-step procedure (Fig. 1): First step included excision of infected or non-viable tissue, if necessary a cover flap is created. The length, alignment, and rotation of the injured limb was obtained comparable to other normal extremity. Method of fixation depended on the fracture type and location. For open fracture, with significant defect, external fixator was used temporarily (Figure 2) and then the cement spacer was placed in the bone defect following debridement and careful stabilization of the fracture fragments. We preferred to use 4 gram Vancomycin in bone polymethyl methacrylate (PMMA) while preparing bone cement spacer (Figure 2). The second step was performed at least 4 to 6 weeks after the first step and included removing the spacer and filling the biological space which has been created with small morsels of cancellous graft, 1–2 mm^3, harvested from the inner cortex of iliac crest . (Figure 3). It may be associated with bone substitutes. This step was performed after any remaining infection has healed. The fracture was approached through the previous incision only.

Figure 1: AP (a) and lateral (b) radiographs of an open fracture right distal femur Gustilo Type IIIA at admission. It was initially debrided, stabilized with an external fixator

Figure 2: AP (a) and lateral (b) radiographs showing fixation with external fixator and screws and placement of antibiotic cement spacer into the defect after the wound had been adequately debrided.

Figure 3: AP (a) and lateral (b) fluoroscopic images of another case Gustilo Type IIIA distal femur showing the fracture stabilized with distal femoral locking plate after removal of cement spacer and the defect filled with cancellous autograft harvested from iliac crest.

Results:

A total of 20 patients were identified within the time period. The series included 18 men and 2 women, with a mean age of 32.5 years (22-46). The bone defects were located at tibia (11 cases) with involvement of the fibula, the femur (6 cases), the humerus (3 cases). Two cases were closed fracture but complicated with infection or nonunion. The other cases were open fractures with bone loss (Gustilo Classification Type II or IIIA).The length of bone defect ranged from 2 cm to 8cm. Primary stabilization of the fracture was ensured by external fixation in all the cases. The antibiotics used for cement spacer was vancomycin. The mean interval between the first-stage and second-stage surgeries was 40 days (30–65). All affected limbs were fixed with screw and plate. All patients showed radiological callus formation over the defect after treatment. Mean time of appearance of callus was 11.5 weeks (6-16 weeks). Consolidation of callus occurred in duration of 12-30 weeks. Non union of long bones united in all cases except one case where complication of breakage of distal femoral locking plate occurred after 5 months of reconstruction surgery. In this case, revision surgery was done with good surgical outcome. The delay between the initial trauma and first stage of the surgical treatment of bone defect was a mean 2.5months (1day- 6 months). All the patients had infection when treatment of bone defect began. Six skin flap covers were performed before actual bone reconstruction.

Evaluation of the size of bone defect was based on radiographic parameters: length of the defect on an AP view of the lateral & medial cortices and lateral views of anterior & posterior cortices.

Discussion:

Treatment of large segmental bone defects can be challenging for orthopaedic surgeons. Masquelet et al. [7] described a procedure combining induced membranes and cancellous autografts. Bone grafting of these defects is often delayed after primary fixation to allow soft tissue healing, decrease the risk of infection, and prevent graft resorption [8]. In the present study, we have treated 20 patients of infected nonunion of long bones with bone gap by using Masquelet technique. It has the advantage of being simple, although has to be technically performed. The two-stage procedure is an advantage in case of infection because the aim of the first step is to cure infection by using antibiotic impregnated cement spacers and restore the envelope of soft tissue. Repeated debridement may be necessary. In traumatic wounds, antibiotic impregnated cement beads or spacers are often used for local antibiotic administration to the soft tissue bed. In addition, the advantages of inserting such a spacer include maintaining a well-defined void to allow for later placement of graft, providing structural support, offloading the implant, and inducing the formation of a biomembrane. Masquelet and Begue proposed that this membrane prevents graft resorption and improves vascularity and corticalization. It has been described that, after the initial placement of the antibiotic impregnated spacer, an interval of 4 to 6 weeks is needed for development and maturation of a biologically active membrane that is suitable for grafting. The spacer also maintains the defect and inhibits fibrous ingrowth [6].

Recent literature has shown that this biomembrane can be 0.5 to 1 mm thick [9] and has been described as both hyper-vascular and impermeable [10]. Viateau et al. [11] studied this technique in a sheep model and found that the membrane alone was inadequate to heal a large defect. But when autologous bone graft was placed within the membrane, all the defects went on to heal.

Aho and his colleagues [12] found that the one-month-old membrane has higher osteogenesis-improving capabilities compared to two-month-old membrane; they concluded that optimal time for performing second-stage surgery may be within a month after implantation of foreign material [12]. In our series, the mean interval between the first and second surgeries is 40 days, which is comparable to other studies.

Pelissier et al. [10] reported that the induced membranes secrete growth factors including vascular and osteoinductive factors and could stimulate bone regeneration.

Accadbled et al. [14] reported a case using a cage and nail construct, resulting in successful eradication of methicillin-resistant staphylococcus aureus infection and reconstitution of a 17 cm diaphyseal defect in the tibia [15]. Apard et al. [17] reported a series of 12 patients who presented with 6 cm segmental defects in the tibia, all of whom were initially fixed with an intramedullary nail. They reported healing following the second-stage procedure in 11 of 12 patients at an average of 4 months.

The technique as described by Masquelet and Begue [6] relied on the placement of morselized cancellous autograft harvested from the iliac crests within the biomembrane lined defect. If this amount is not sufficient, demineralized allograft is added to the autograft in a ratio that does not exceed 1:3. In our study, we used autograft harvested mainly from iliac crest, without any allograft. Biau et al. [13] used both iliac crest corticocancellous autograft and a medial tibial cortical strut autograft to fill their large defect. Schmidmaier et al. [18] described the use of cancellous autograft from the femoral canal. They showed that levels of many growth factors (fibroblast growth factor-α, platelet derived growth factor, insulin-like growth factor 1, TGF-1, and BMP-2) in femoral cancellous bone are present in higher concentrations than they are in iliac crest and platelet preparations In our study, we used Masquelet technique to treat infected post-traumatic bone defect successfully.

Conclusion:

In conclusion, successful reconstruction of extensive bone defects is possible with the induced membrane technique of Masquelet. The technique of delayed bone grafting after initial placement of a cement spacer provides a reasonable alternative for the challenging problem of significant bone loss with infection in long bones. The bioactivity of the membrane created by filling large bony defects with cement leads to a favourable environment for bone formation and osseous consolidation of a large void. The technique is simple and advantageous in cases of primary infection also.

Conflict of Interests:

The authors declare that they have no conflict of interests, any grant, or financial profit related to this clinical study. This study received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

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