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Original Article

Results of Masquelet Technique in the Treatment of Tibial Gap Non-Union: A Prospective Study in Lower Assam

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ABSTRACT

Introduction: Infected nonunion of tibia per se is a challenge to treat. Subcutaneous bone causes susceptibility to non-responsive infection, nonunion, fibrosis, sinuses, deformities, shortening and various other sets of problems which are associated with it. Different methods of treatment have been recommended for management of infected nonunion. The first is the "conventional" or classic method. The objectives of the conventional method are to convert an infected and draining nonunion into one that has not drained for several months and to promote healing of the nonunion by bone grafting. This method of treatment often requires one or more years to complete and usually results in stiffness of adjacent joints. The objective of the second i.e. active method is to obtain bony union early and shorten the period of convalescence and preserve motion in the adjacent joints. After restoration of bony continuity, all devitalized and infected bone and soft tissues are removed. Then the fragments are aligned and stabilized, usually by an external fixation device.2

Materials and Methods: The present prospective study was carried out in the Department of Orthopaedics, BMCH, Barpeta. Total of twenty five patients with infected nonunion of tibia of either sex were included in the studyand were treated by Masquelet`s technique. After an informed consent for inclusion into the study, a detailed history was taken including the mode of injury and treatment taken prior to admission. A detailed examination was done to assess the current status of patient including presence of sinuses, knee and ankle range of motion, deformity, limb length discrepancy and neurovascular deficit. Associated injuries were noted, if any. Pus culture was sent. Standard anterio-posterior (AP) and lateral radioraphs of fractured bones were done and fractures were classified according to Paley al17 classification. Patients were subjected to all relevant pre-operative investigations like Hb, BT, CT, Blood urea, Blood sugar, Serum Na+/K+ ,Complete urine examination, ECG, Chest X ray- PA view etc. All the history and clinical findings were documented in the proforma made for this purpose.

Results: Mean gain in length was 3.458 cm (Range; 3-6 cm) as there was no corticotomy done there was no gain in length but the gap was maintained with exact length of bone cement in stage I followed by bone graft in stage II surgeries , which mean value was 3.458 cm (P value = 0.057, by independent t-test, statistically significant). In a study Dendrinos et al28 reported treatment of non-union of the tibia associated with infection in 28 patients. The size of the bone defect that was bridged averaged 6 cm (range, 2 to 13 cm). Magadum et al44 studied 27 men infected nonunion. The mean lengthening achieved was 10 cm. Thus findings of the present study were comparable to findings in literature.

Conclusion: Masquelet technique has the potential to correct infection, deformity, bone and soft tissue loss and limb length discrepancy simultaneously. It is capable of giving good to excellent results in infected nonunion of tibia. The functional and radiological results were found to be very satisfactory with Masquelet technique . Duration of fixator period and non union could be improved

significantly with Masquelet technique despite of bone gap. A larger prospective study is recommended to further differentiate and give clear cut guidelines in such challenging group of patients.

Keywords*:* Infected Nonunion of Tibia, Masquelet Technique, Bone Defect Reconstruction, External Fixation, Limb Length Discrepancy.

INTRODUCTION

A nonunion following fracture is a major orthopaedic problem. The presence of infection and bone loss complicates the management of these fractures. Soft tissue damage and periosteal stripping are common in high velocity and open injuries and this can compromise the vascularity to the soft tissues around the fracture. Nonunion is more common when the fractures are open, infected, segmental, with impaired blood supply, comminuted by severe trauma, insecurely fixed, immobilized for an insufficient time, treated by ill-advised open reduction, distracted either by traction or by a plate and screws or of irradiated bone.1

Infected nonunion of tibia per se is a challenge to treat. Subcutaneous bone causes susceptibility to non-responsive infection, nonunion, fibrosis, sinuses, deformities, shortening and various other sets of problems which are associated with it. Different methods of treatment have been recommended for management of infected nonunion. The first is the "conventional" or classic method. The objectives of the conventional method are to convert an infected and draining nonunion into one that has not drained for several months and to promote healing of the nonunion by bone grafting. This method of treatment often requires one or more years to complete and usually results in stiffness of adjacent joints. The objective of the second i.e. active method is to obtain bony union early and shorten the period of convalescence and preserve motion in the adjacent joints. After restoration of bony continuity, all devitalized and infected bone and soft tissues are removed. Then the fragments are aligned and stabilized, usually by an external fixation device.2

Masquelet technique is a relative new technique used in the management of large bone defects. It is based on two principles or operative stages:

1. The formation of induction membrane. After bone debridement, the defect is filled with bone cement. The cement is kept for a period of six to eight weeks. This allows the formation of induction membrane.
2. Cancellous bone grafting. After a period of six to eight weeks, the bone cement is gently removed. The defect is filled with cancellous bone graft. Defects as large as 25cm can be managed using the Masquelet technique.6

The first stage in Masquelet's technique is mechanical: the bone cement provides additional support to the limb and maintains the defect. The primary stability is usually provided by an external fixator. Intramedullary device may also be used as a primary stabilizer. The induction membrane is formed at this stage. The second stage is a biological one. This is the stage that has been studied extensively in a large number of experiments. It has been demonstrated that periosteal flap wrapped around the cancellous bone exerts a protective effect against bone resorption in muscle tissue. The cancellous bone is capable of forming bone even without stress to the bone. But the cancellous bone will resorb if the recipient bed is poorly vascularized.7

MATERIALS

The present prospective study was carried out in the Department of Orthopaedics, BMCH, Barpeta. Total of twenty five patients with infected nonunion of tibia of either sex were included in the studyand were treated by Masquelet`s technique.

INCLUSION CRITERIA:

- Patients with infected nonunion of tibia.
- Patients were considered to have nonunion if:

(A) Patient having ununited fracture of tibia with fracture line visible on radiograph.
(B) Gap of <6 cm at the fracture site.
Patients were considered to have infection if patient had discharging sinus at the fracture site or positive swab culture from wound.

EXCLUSION CRITERIA:

- Patients with periarticular nonunion, pathological fractures and fractures associated with bone disorders, presence of any debilitating systemic disease, hormonal disorders were excluded from the study.

METHODS:

After an informed consent for inclusion into the study, a detailed history was taken including the mode of injury and treatment taken prior to admission. A detailed examination was done to assess the current status of patient including presence of sinuses, knee and ankle range of motion, deformity, limb length discrepancy and neurovascular deficit.

Associated injuries were noted, if any. Pus culture was sent. Standard anterio-posterior (AP) and lateral radioraphs of fractured bones were done and fractures were classified according to Paley al17 classification. Patients were subjected to all relevant pre-operative investigations like Hb, BT, CT, Blood urea, Blood sugar, Serum Na+/K+ ,Complete urine examination, ECG, Chest X ray- PA view etc. All the history and clinical findings were documented in the proforma made for this purpose.

PROCEDURE:
Assessment of the clinical and radiological status of the fracture was done. Patients were taken up for surgery as soon as he/she was fit for anaesthesia. Surgeries were performed under anaesthesia. All previously used implants, if any, were removed. A longitudinal or an appropriate incision was given as per need of local soft tissue status. Radical resection of all necrotic tissue including bone was done. Fractures were stabilized monolateral fixator. Three clamps were applied with 8 or 9 tapered threaded pins over rail system.

MASQUELET TECHNIQUE:
It is based on two principles i.e two stages of surgery.
The formation of induction membrane: After bone debridement, the defect is filled with bone cement. The cement is kept for a period of six to eight weeks. This allows the formation of induced membrane.

Cancellous bone grafting: after a period of six to eight weeks,the cement is gently removed. The defect is filled with cancellous bone graft.

Surgical technique
The first step in this technique is the formation of induction membrane. It forms around the bone cement. The membrane serves a very critical function: protection of cancellous bone graft from the body`s immune system. This prevents cancellous bone resorption.

The first stage in Masquelet`s technique is mechanical: the bone cement provides additional support to the limb and maintain the defect. The primary stability is usually provided by an external fixator. Intramedullary device may also be used as a primary stabilizer.the induction membrane is formed at this stage.

Figure 1 : Clinical photograph showing bone gap after debridement of sclerotic bone

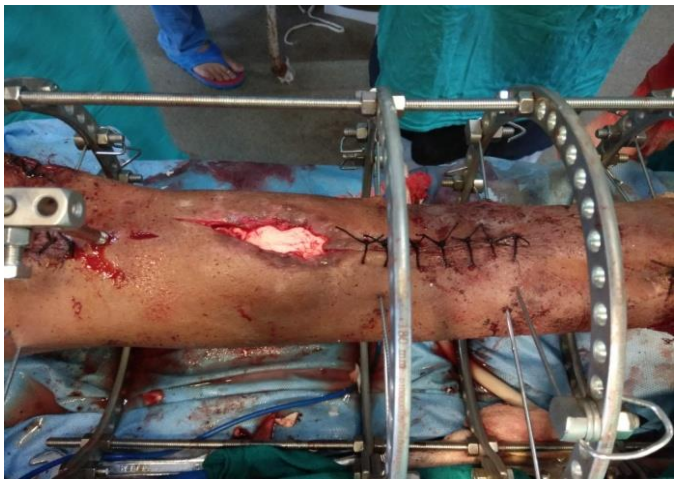


Figure 2 : Clinical photograph showing bone cement application after debridement of sclerotic margins

The second stage is a biological one. The second stage of bone grafting is performed 6-8 weeks after the first surgery. The fracture is approached through the previous incision and careful dissection performed down to the defect. The biomembrane encapsulating the cement spacer is carefully incised. Once exposed, the cement spacer is removed and the biomembrane capsule is irrigated to remove any residual debris. With the defect being open,bone graft is placed to fill the entire defect. The defect should be completely filled but not overstuffed. Once the defect is filled, the biomembrane is closed with absorbable suture. The cancellous bone is capable of forming bone even without stress to the bone. But the cancellous bone will resorb if the recipient bed is poorly vascularised.

The resultant induced membrane was found to be effective in containing the graft materials in situ. It was demonstrated to be an organized pseudosynovial membrane which expressed

- Bone morphogenic protein 2 (BMP-2)
- Transforming growth factor-beta (TGF-B)
- Von Willebrand factor (vWF)
- Interleukin6 (IL-6) and Interlekin8 (IL-8).

POST OPERATIVE PERIOD :

The pin tracts were sealed with Povidone-Iodine soaked gauze pieces. Patients were encouraged to ambulate from the first post-operative day with crutch walking and partial weight bearing. Patients were taught pin care & method of distraction. Exercises were advised to patient to prevent contracture and stiffness. Sutures were removed on the 10-14th post-operative day. Patients were followed up at monthly intervals for a minimum of 6 months or until union whichever is earlier. At each clinical follow up, the patients were assessed clinically and radiologically. Assessment of complications like muscle contractures, joint subluxation, axial deviation, neurological or vascular insult, premature consolidation, delayed consolidation, refracture and pin-site infection was done at each follow up visit and were managed accordingly. Pin tract infections were classified according to Paley's classification5 in to grade 1, grade 2 and grade 3. Grade 1 and grade 2 infections were grouped together for statistical calculations and labeled as "Superficial pin tract infections". Grade 3 infections were labeled as "Deep pin tract infections".

Bone results	
Excellent	Union, no infection, deformity < 7°, limb length discrepancy < 2.5 cm.
Good	Union + any two of the following: no infection, deformity < 7°, limb length discrepancy < 2.5 cm.
Fair	Union +only one of the following: no infection, deformity < 7°, limb length discrepancy < 2.5 cm.
Poor	Nonunion / refracture / union + infection + deformity > 7° + limb length discrepancy > 2.5 cm.
Functional results	
Excellent	Active, no limp, minimum stiffness (loss of <15°knee extension/ < 15° dorsiflexion of ankle), no reflex sympathetic dystrophy (RSD), insignificant pain.
Good	Active with one or two of the following: Limp, stiffness, RSD, significant pain.
Fair	Active with three or all of the following: Limp, stiffness, RSD, significant pain.
Poor	Inactive (unemployment or inability to return to daily activities because of injury).
Failure	Amputation

OBSERVATION & RESULTS

Table 1 : Distribution by pus culture

PUS CULTURE	E. Coli	Count	6
		% within Group	24.0%
	Klebsiella	Count	4
		% within Group	16.0%
	Staphylococcus	Count	15
		% within Group	60.0%
Total		Count	25

	% within Group	100.0%

Most common infective agent in this study group was Staphylococcus (60 %)

Table 2: GAIN IN LENGTH (cm)

		GAIN IN LENGTH (cm)
Masquelet technique	Mean	3.458
	N	12

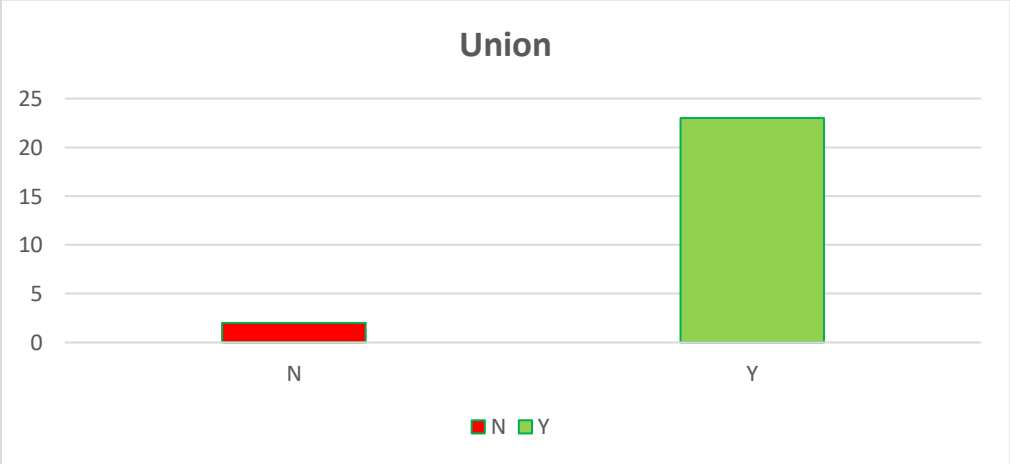
There was no gain in length but the gap was maintained with exact length of bone cement in stage I followed by bone graft in stage II surgeries. which mean value was 3.458 cm (P value = 0.057, by independent t-test, statistically not significant).

Table 3: DURATION OF FIXATOR (months)

		DURATION OF FIXATOR (months)
Masquelet technique	Mean	16.417
	N	12
	Std. Deviation	1.6214
P value	<0.001	

Average fixator period was 16.417 months (Range; 13-18 months), (P value <0.001, by independent t-test, extremely statistically significant).

Table 4 : Union



Union was achieved in 23 patients (92.0%). Two patients (8.0%) had nonunion. P value is <0.05.

Table 5: Functional results

Functional results were excellent in 11 patients, fair in 10, good in 3 with poor results only in 1 patient (P value = 0.26, by Chi square test).

Overall most common infective agent in this study was Staphylococcus (15 patients, 60%) , followed E.Coli (6 patients, 24%) and Klebsiella (4 patients, 16%). Yin et61 al evaluated 66 patients with infected tibial nonunion. The samples that were obtained from purulent drainage or bone at the site of infected nonunion were cultured. Bacterial species grown in culture were Staphylococcus aureus in 47%, Pseudomonas aeruginosa in 16%, Escherichia coli in 13%, Klebsiella in 9%, Enterococcus in 6%, Acinetobacter in 3%, Serratia in 3%, Proteus in 1%, Burkholderia cepacia in 1% and Candida in 1% patients. Siboni et al67 conducted a study on management of septic non union of the tibia by Masquelet technique in which they have found Staphylococcus to be most common association with infection(89%) Staphylococcus was found to be the most common infective agent in present study as well as in above mentioned studies.

Mean gain in length was 3.458 cm (Range; 3-6 cm) as there was no corticotomy done there was no gain in length but the gap was maintained with exact length of bone cement in stage I followed by bone graft in stage II surgeries, which mean value was 3.458 cm (P value = 0.057, by independent t-test, statistically significant). In a study Dendrinos et al28 reported treatment of non-union of the tibia associated with infection in 28 patients. The size of the bone defect that was bridged averaged 6 cm (range, 2 to 13 cm). Magadum et al44 studied 27 men infected nonunion. The mean lengthening achieved was 10 cm. Thus, findings of the present study were comparable to findings in literature.

Average fixator period was16.417 months (Range; 13-18 months), (P value <0.001, by independent t-test, statistically significant).). In a study conducted by Tong et al65 evaluated the effectiveness of Masquelet technique and Ilizarov bone transport in lower extremeties bone defects following post traumatic osteomyelitis, the mean finite fixator time was 10.15 months (range,8-14 months) in group A versus 17.21 months (range, 11-24 months) in group B . The fixator period in Group II patients (16.41 months) was more than Group I patient (10.88 months). The fixator period in our study is comparable to the various studies in the literature.

Union was achieved in 23 patients (92%). Nonunion occurred in 8 % patients. Hosny et al30 reported a union rate of 100 % in a study of 11 patients. Chaddha et al54 reported a union rate of 92%. Other studies33, 43,61 also reported 100 % union rate. Patil et al41 reported union in 39 (95%) out of 41 cases. Siboni et al67 reported a union rate of 17 of the 19 cases (89.0%). Kasha et al68 reported a union rate of 100% in their study. Our results, in terms of union, were comparable with various studies reported in literature.

Functional results were Excellent in 11 patients (44 %), good in 10 patients (40 %), (4%) poor functional result. 3 patient (12%) had fair outcome. Functional results of present study were comparable to studies reported in literature.

CONCLUSION

Masquelet technique has the potential to correct infection, deformity, bone and soft tissue loss and limb length discrepancy simultaneously. It is capable of giving good to excellent results in infected nonunion of tibia. The functional and radiological results were found to be very satisfactory with Masquelet technique. Duration of fixator period and non union could be improved significantly with Masquelet technique despite of bone gap. A larger prospective study is recommended to further differentiate and give clear cut guidelines in such challenging group of patients.

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