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Prospective randomized comparison of bone transport versus Masquelet technique in infected gap nonunion of tibia

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Abstract

Aim The present prospective randomized study compared the bone transport technique (BT) and Masquelet technique (MT) in the treatment of infected gap non-union of the tibia.

Patients and methods Total 25 patients with infected gap non-union of the tibia with bone gap upto 6 cm were randomised into BT group (group I, 13 patients) and MT (group II, 12 patients). The mean age was 31.77 years in group I and 39.67 years in group II. The mean intra-operative bone gap was 3.92 cm in group I and 3.79 cm in group II. Monolateral fixator was applied in nine patients each in both groups, while four and three fractures were stabilized with ring fixators in group I and II, respectively. Mean follow-up was 31.62 months and 30.42 months in group I and II, respectively. Bone and functional results were compared using the association for the study and application of the method of Ilizarov (ASAMI) criteria.

Results The average fixator period was 9.42 and 16.33 months in group I and II, respectively ($p < 0.001$). Union was achieved in 12 (92%) patients and 6 (50%) patients in group I and II, respectively. The functional results were excellent (eight and two), good (four and six), fair (zero and three) and poor (one and one) in group I and II respectively, (p 0.23). The Bone results were excellent, good and poor in nine, three and one patients in group I, and three, three and six patients in group II respectively, (p 0.109).

Conclusions The functional and bone results were comparable but more reliable in bone transport than the Masquelet technique. The fixator duration and incidence of non-union were higher in MT group. Ilizarov bone transport technique should be preferred in infected non-union of the tibia with bone loss upto 6 cm.

Keywords Bone gap · Infected non-union · Tibia · Ilizarov · Bone transport · Masquelet technique · ASAMI criteria · Bone results · Functional results

Introduction

Incidence of infections in high-velocity compound-complex bone injuries is more prevalent in recent era due to high contaminations at road side accidents (RSA) and severe musculoskeletal insult ranging from 4 to 64% [1, 2]. Further infected gap bone defects are resilient to long course of antibiotics and surgical treatment makes this entity cumbersome to treat efficiently [2]. There are a number of modalities described in literature at different time with their varied successful outcomes including Ilizarov bone transport technique, Masquelet (induced membrane) technique, bone grafting in form of vascularized autograft or allografting, different mesh techniques and more recently bone morphogenic proteins and tissue engineering products [2–9]. Ilizarov bone transport is one of the most successful and worldwide accepted method of treatment for infected non-union of the tibia. It usually involves adequate debridement of necrotic and infected bone followed by corticotomy for distraction osteogenesis [4, 8–13]. On the other end two staged Masquelet technique involving radical debridement followed by antibiotic cement spacer in first stage and

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cancellous bone grafting within induced biomembrane after removal of spacer at 6–8 weeks in second stage gained much popularity with high successful rate [4, 5]. There is scarcity of documented English literature comparing both modalities in the management of infected bone gap defects of tibia. We conducted a prospective randomized study to compare Ilizarov bone transport and Masquelet techniques in management of infected gap non-union of the tibia with respect to union, functional outcome and related complications.

Materials and methods

The present prospective randomized comparative study included 25 patients of infected non-union of tibia presenting to author's tertiary level institute between Jun 2016 and Dec 2018. Patients with posttraumatic infected nonunion of tibia having fractures of tibia with fracture line visible on radiographs and bone gap of < 6 cm with adequate soft tissue cover of the bone were included in the study. Subjects were considered to have an infection, if they either had active discharging sinus at the fracture site or positive swab culture from wound/sinus [4, 9]. Intraoperative tissue samples, as well as hislopathological examination, was used to confirm the infection as well as pathology. Any wound more than 1.5 cm in any dimension over fracture site was considered as inadequate soft tissue cover. Patients with periarticular nonunion, bone gap > 6 cm, age > 65 years and < 18 years, pathological fractures and fractures associated with bone disorders, presence of any debilitating systemic disease and any underlying hormonal disorders were excluded from the study. The majority of patients were young with high-velocity trauma, so having no comorbid conditions. Comorbid conditions can adversely affect outcomes in other group, so to maintain comparable groups these were excluded from both groups in present study.

A detailed history and careful physical examination were done to extract relevant data. With standard anterio-posterior and lateral radiographs of fractured bones, these were classified according to Paley al classification [1, 3]. Patients were subjected to all relevant pre-operative investigations for pre-anaesthesia fitness. Baseline pre-op erythrocyte sedimentation rate (ESR), C-reactive protein (CRP) and pus cultures were sent for all the subjects for future treatment and diagnostic guidance.

Surgical methods of debridement and primary stabilization

All the procedures were done under regional or general anaesthesia in a supine position with all aseptic precautions. A longitudinal or appropriate incision over the previous scar or fresh one as per need of local soft-tissue status was given over the non-union site. Previously used hardware in situ, if any persist, were removed and radical resection of all necrotic tissue including bones upto appearance of vital tissue or fresh bleeding at the bone ends was done. Intraoperative tissues were sent for pus culture and sensitivity as well as histopathological examination to confirm the infection as well pathology [14].

Randomization was done by chit/lottery method during the operative procedure, if the patient had post debridement bone gap ≤ 6 cm. Thirteen patients were treated with bone transport technique (group I) and 12 patients by Masquelet's technique (group II).

Group (Gp) I (bone transport technique)

Fracture ends of the bone were stabilized with either ring fixator or monolateral (Limb Reconstruction System LRS, Pitkar, India) external fixators. Ring fixators were applied in the standard manner with four rings and four rods around the affected limb by measuring the rings in reference to the greatest circumference of the limb with additional two finger breadth increments for ring skin clearance both anteriorly and posteriorly. Total 10 wires measuring 1.8 mm diameter were passed through the safe zone for bone fixation. Wires were passed slowly, intermittently while limb muscles were kept in maximal functional length at the time of wire insertion. Corticotomy was done at a single level in all patients either at proximal, distal or mid-diaphyseal level after application of fixator depending upon the fracture level and bone gap. Wound margins were approximated loosely as possible as and relaxing incisions were given, if needed. Similarly, for monolateral fixators, device was mounted on the anteromedial subcutaneous surface of the tibia by placing pins parallel to the axis of the knee joint and perpendicular to long axis of the tibia with three clamps aligned by eight or nine tapered threaded pins. Throughout the procedure, utmost attention was given to keep the fracture aligned in both planes. All the patients were given intravenous antibiotics for 2 weeks which were switched off over oral antibiotics for further 2 weeks according to culture sensitivity.

Group II (Masquelet technique)

The two staged surgery performed in a standard manner as described in the literature [6, 7]. At first mechanical stage, after thorough radical debridement as mentioned earlier, created bone gaps were filled with the antibiotic impregnated bone cement (PMMA), which also maintained the bone length. The limbs were fixed with external fixators (ring or LRS) for 6–8 weeks in normal alignment. Intravenous antibiotics were given for two weeks followed by oral antibiotics for two weeks depending on intraoperative culture sensitivity report. Patients had no signs of infection at end of the first stage confirmed by the absence of pus discharge, normal ESR and CRP. At the second biological stage, integrated PMMA spacer over the defects were removed meticulously without disturbing the surrounding soft tissues and induced membrane over the cement. Defect was filled with cancellous bone autograft from iliac crests followed by wound closure in layers by approximating skin ends in a delicate manner. The fixation used in the first stage was continued in the second stage also. Patients had intravenous antibiotics for one week followed by oral antibiotics till suture removal after the second stage.

Post-operative care and rehabilitation

The pin tracts were sealed with Povidone-iodine soaked gauze pieces dressed at regular intervals. Patients were encouraged to ambulate from the very first post-operative day with partial weight-bearing while the active and passive range of movement exercises started simultaneously to prevent contracture and stiffness. Distraction at corticotomy site in Gp I was started on the seventh day at the rate of 1 mm/day (0.25 mm four times a day) and sutures were removed on the 12–14th post-operative day. Patients were followed sequentially at monthly intervals for a minimum of 6 months or until union appeared clinically and radiologically. At each follow-up assessment and management of complications, if any, was done. Pin tract infections were classified as superficial (grade 1 and 2) and deep infections (grade 3), according to Paley's classification [1, 4]. Healing in form of union is considered radiologically if three of four cortices showed bridging callus while clinically if there was absence of pain and motion at the fracture site.

Frames were dynamized before removal. Frames were removed after achieving union at fracture sites and consolidation at corticotomy sites. After removal of the fixator frames, PVC (polyvinyl chloride) below knee brace was given for the next 6 months and progressive weight-bearing was allowed. Final assessment for bone results and functional results was done using Association for the study and application of the methods of Ilizarov (ASAMI) criteria (Table 1) [4, 8]. The relevant data was analyzed statistically by appropriate tests including the Chi-square test with Yates correction, Fisher exact test and independent student's *t* tests using IBM SPSS Statistics Version 20 software while p value ≤ 0.05 was considered statistically significant.

Results

Demographic profile and operative data of both the groups are described in Table 2. There was no statistically significant difference between the two groups on the basis of age, sex, mode of injury, site of injury, side of injury, duration of nonunion, intraoperative bone gap, and follow-up period. Monolateral fixator was applied in nine patients each in both groups, while four and three fractures were stabilized with ring fixators in Gp I and II, respectively, (p 0.89). Mean intraoperative bone gap was 3.92 ± 0.86 cm (range 3–6 cm) and 3.79 ± 1.19 cm (range 2–6 cm) in Gp I and II, respectively (p 0.754). Corticotomy in group I was performed in nine and four patients at proximal and distal tibia respectively, whereas no corticotomy was done in group II. Mean gain in length with distraction osteogenesis was 3.85 ± 0.898 cm (range 3–6 cm) in group I whereas in group II, the gap was maintained with the exact length of bone cement in stage I followed by bone graft in stage II with a mean value of 3.79 ± 1.19 cm (p 0.898).

The average fixator period was 9.42 ± 2.37 months (range 6–12 months) and 16.33 ± 1.82 months (range 13–18 months), in group I and II respectively ($p < 0.001$, extremely significant). The average external fixator index (number of months the external fixator was attached to the bone per centimeter of length gained) was 2.486 ± 0.56 months/cm in Gp I and $4.71 + 1.71$ months/cm in Gp II ($p < 0.002$, extremely significant). Fixator adjustment to correct axial deviation was required in two (15.4%) patients in Gp I and one (8.3%) patient in Gp II (p 0.94). Acute docking was done in one patient in Gp I only. In Gp I, the union was achieved primarily in 10 patients and after margin freshening and fixator adjustment in two more patients. So union was achieved in 12 (92%) patients and 6 (50%) patients in Gp I and II, respectively. Radiographic illustrations of treatment of infected non-union tibia with Ilizarov bone transport are described in Fig. 1. Non-union occurred in 50% (six) patients in Gp II as compared to one (8%) in Gp I, (p 0.056). Two patients among six failures in Gp II were managed with refreshening of non-union ends and refixation with bone transport technique while two limbs were managed with functional cast bracing with adequate functional outcomes. Two patients in Gp II were managed with below-knee amputation as insisted by patients.

Radiographic illustrations of failed treatment of infected non-union tibia with Masquelet technique and revision surgery with Ilizarov bone transport is described in Fig. 2. No patient had a persistent infection at fracture site in any of the group. Cement spacer got exposed in four patients in Gp II at end of the first stage.

Limp was present in three patients (23.07%) in Gp I and nine patients (75%) in Gp II (p 0.028, statistically significant). Significant stiffness of knee, ankle, and both joints (loss of $\geq 15°$ knee extension and ankle dorsiflexion) were observed in zero, three, two and two, zero, two patients in Gp I and II respectively. Bone results were excellent in nine, good in three and poor in one patient in Gp I, whereas excellent, good and poor in three, three and six patients, respectively in Gp II. (p 0.109). Functional results were excellent

Table 1 Assessment for bone results and functional results using association for the study and application of the methods of Ilizarov (ASAMI) criteria

	Bone results	Functional results
Excellent	Union, no infection, deformity < 7°, limb length discrepancy < 2.5 cm	Active, no limp, minimum stiffness (loss of < 15° knee extension/ < 15° dorsiflexion of ankle), no reflex sympathetic dystrophy (RSD), insignificant pain
Good	Union + any two of the following: No infection, deformity < 7°, limb length discrepancy < 2.5 cm	Active with one or two of the following: Limp, stiffness, RSD, significant pain
Fair	Union + only one of the following: No infection, deformity < 7°, limb length discrepancy < 2.5 cm	Active with three or all of the following: Limp, stiffness, RSD, significant pain
Poor	Non-union/refracture/union + infection + deformity > 7° + limb length discrepancy > 2.5 cm	Inactive (unemployment or inability to return to daily activities because of injury)
Failure	Not applicable	Amputation

(eight and two), good (four and six) and poor (one and one) in Gp I and II respectively, while three patients from Gp II had fair outcome (*p* 0.23).

Discussion

Management of infected non-union of the tibia to incorporating eradication of infection along with gaining pre-injury functional outcome is a cumbersome task. There are several modalities to overcome infection and associated problems in different forms, including traditional Ilizarov bone transport and newer one Masquelet technique [2–13]. The primary and utmost principle is to eradicate infection with meticulous debridement in all modalities followed by bong grafting or bone regeneration and aligned stable fixation of fracture ends [4]. Ilizarov bone transport methods can address both osseous and soft-tissue defects simultaneously using principles of distraction osteogenesis [4, 8, 9]. Masquelet technique has the additional advantage of use in small bones including hand and foot and periarticular defects [6, 7, 15–18].

Pseudo-synovial membrane around the cement spacer in MT while providing some vascular bed for graft incorporation with host bone, may act as a protective layer for bone graft against host immune system thus hampers graft resorption additional to the expression of various growth factors including bone morphogenic protein 2 (BMP-2), transforming growth factor-beta (TGF-B), Von Willebrand factor (VWF), interleukin6 (IL-6) and interlekin8 (IL-8) etc. [5, 7].

According to the literature there are comparable outcomes in view of treatment duration, complications, patient compliance, and satisfaction for both the methods of external fixation, Ilizarov as well as monolateral external fixators [4, 5, 9]. The mean duration of fixator was significantly higher in Gp II than I (16.33 vs 9.42), inspite of less mean bone gap (3.79 cm vs 3.92 cm), which was different in the study by Tong et al. [5] (10.15 months vs 17.21 months) for post-traumatic osteomyelitis bone defects in lower extremities. Average external fixation index of the present scenario was (2.48 months/cm in Gp I and 4.71 months/cm in Gp II) which was more than Yin et al. [19] (1.38 months/cm) and Chaddha et al. [8] (0.98 months/cm) and Ajmera et al. [20] (1.88 months/cm) while comparable to Hosny et al. [21] (2.30 months/cm) for Ilizarov BT group.

Our results, in terms of union (92%) in Gp I were comparable with various studies reported in the literature [19, 22, 23]. We are of the opinion that achievement of union is more reliable and predictable with bone transport technique than Masquelet technique in infected nonunion of the tibia with bone gap upto 6 cm.

Comparison of functional results and bone results by ASAMI criteria of the present study with document

Table 2 Demographic profile and operative data of group I (bone transport) and group II (Masquelet technique)

S. no.	Parameters	Bone transport (Gp I) ($n = 13$) (mean ± sd) (range)	Masquelet tech (Gp II) ($n = 12$) (mean ± sd) (range)	p value test
1	Mean age (years)	31.77 ± 14.87 (18–60)	39.67 + 14.06 (25–60)	0.186[a]
2	Male			
	female	12:1	11:1	0.46[b]
3	Side (right/left)	5/ 8	4/ 8	0.88[b]
4	Mode of injury (RSA/fall from height)	12/ 1	12/ 0	
5	Site of fracture (proximal/middle/distal third of tibia)	3/ 4/ 6	2/ 9/ 1	0.168[b]
6	Gustilo Anderson classification			0.96[b]
	Closed	1	0	
	Open Grade II	2	4	
	IIIA	3	2	
	IIIB	7	6	
7	Soft tissue procedures (split skin grafting or flap) prior to enrollment into the study	3	4	0.899[b]
8	Duration of non-union (months)	7.31 ± 2.5 (5–12 months)	7.17 ± 1.75 (4–10 months)	0.87[a]
9	Previous treatment cast/locked compression plate/ intramedullary nailing/ external fixation	0/ 1/ 2/ 10	2/ 1/ 3/ 6	0.71[b]
10	Fracture classification by Paley et al. [1] A1/ A2/ B1/ B2/ B3	3/ 1/ 5/ 3/ 1	1/ 3/ 7/ 0/ 1	0.68[b]
11	Mean intra-operative bone gap (cm)	3.92 ± 0.86 (3–6)	3.79 ± 1.19 (2–6)	0.754[a]
12	Fixator parameters			
	Duration of external fixator (months)	9.42 ± 2.37 (6–12)	16.33 ± 1.82 (13–18)	< 0.001[a]
	Fixator index (month/cm)	2.486 ± 0.56	4.71 ± 1.71	< 0.002[a]
	Type fixator (Ilizarov ring/LRS)	4/ 9	3/ 9	0.89[b]
	Need of fixator adjustment	2 patients (15.4%)	1 patient (8.3%)	0.94[b]
13	Gain in mean length (cm)	3.85 ± 0.898	3.79 ± 1.19	0.898[a]
14	Post-op follow-up duration (months)	31.62 + 3.69 (24–37)	30.42 + 4.81 (24–36)	0.489[a]
15	Complications			
	Non-union	1	6	0.056
	Limb length discrepancy	1 (1 cm)	1 (1 cm)	0.49
	Pin loosening	1 (single pin)	0	0.96
	Deformity > 7°	1	3	0.52
	Reflex sympathetic dystrophy	1	0	0.96
	Limp	3	9	0.028
	Superficial pin tract infection	9	6	0.567
	Deep pin tract infection (monolateral fixators only)	3	4	0.899

[a] Independent *t*-test

[b] Chi-square test with Yates correction

literature in past is tabulated in Table 3, 4, respectively. Functional and bony results were statistically non-significant between the groups while Gp I represented better results than Gp II [5, 8, 19–21], [24–26]. The excellent bone result was achieved in nine patients (69.2%) in Gp I as compared to only three (25%) in Gp II, (p 0.07). Similarly, excellent functional outcome was more common in Gp I (eight patients, 61.5%) than in Gp II (two patients, 16.6%), (p 0.06). This underlines the fact that more patients in Gp II had residual problems than Gp I. This further supports our opinion that achievement of good to excellent functional and bone results are more predictable with bone transport technique as compared to Masquelet technique in patients of infected nonunion of tibia with bone loss upto 6 cm. Bone transport technique also aids in the treatment of soft tissue defects as soft tissue also regenerates along with bone [4], [8–13], [19–26]. While the availability of adequate amount of autogenous cancellous Iliac bone grafts can be an issue for the reconstruction of major bone defect which can be addressed with use of

Fig. 1 **a** Preoperative radiograph (antero-posterior view) of right leg showing compound fracture of tibial mid-shaft and segmental fracture of the fibula. **b** Temporary stabilization of fractures of both bones with external fixator as damage control orthopedics resulting as infected non-union of the tibial diaphysis. **c** Immediate postoperative radiograph of right leg antero–posterior view, showing Ilizarov fixator stabilization after radical debridement of infected bone ends and proximal metaphyseal corticotomy of tibia. **d** Antero-posterior radiographic view of limb at final follow up showing consolidation of regenerate at proximal metaphyseal site and union at the fracture site with the adequate alignment of the limb. **e** Lateral radiographic view of limb at final follow up showing consolidation of regenerate at proximal metaphyseal site and union at fracture site with adequate alignment of limb

femoral medullary grafts by RIA (Reamer irrigator aspirator) technique, allogenic bone or demineralized bone substitute [2, 3, 7]. There was an additional surgical insult at bone graft harvesting site, which further deranged mobility status of the patient at immediate post-operative period [5–7]. There were four cases of cement spacer exposure

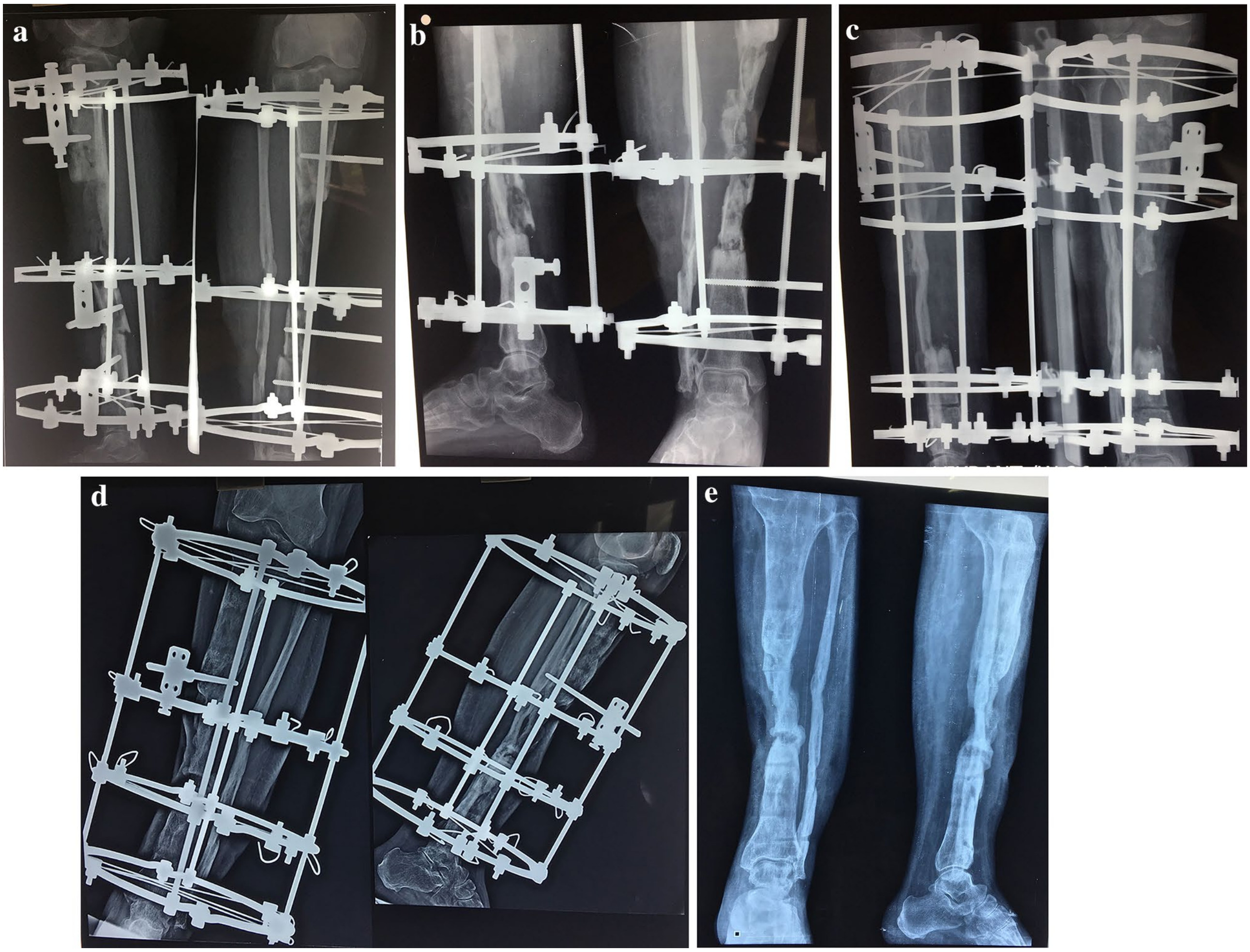

Fig. 2 **a** Antero-posterior and lateral views of radiograph showing infected non-union of tibia managed with Masquelet technique and cement spacer in situ. **b** Radiographs showing failure of Masquelet technique and resorption of bone graft with sequestrum formation at grafting site. **c** Radiographs showing revision surgery with re-debridement and proximal metaphyseal corticotomy in failed Masquelet technique. **d** AP and lateral radiographs showing aligned limb with union at fracture site and regenerate formation at corticotomy site stabilized with Ilizarov bone transport technique. **e** AP and lateral radiographs showing complete union at the fracture site and consolidation of regenerate with the adequate alignment of the limb at corticotomy site at final follow-up

in Gp II, which might be related to soft tissue overlying non-viable bone cement or compromised soft tissue over the defects or overstuffing of the cement [7, 27–29]. These patients had no signs of reinfection at end of first stage confirmed by the absence of pus discharge, normal ESR and CRP values. Pin tract infection was the most common complication and were comparable in both groups. Similarly, joint stiffness was also comparable in both groups. Limping was observed more in Gp II and related to the stiffness of knee and ankle joints, shortening of limb, and more incidence of nonunions in Gp II. These all complications were also comparable to past literature [27–33]. The combined ortho-plastic approach has also some good results in the management of these complex injuries and has low complication rates documented in recent English literature [32]. There are some advantages of using bone transport technique over Masquelet technique [5] in terms of early allowance of weight-bearing, possibility of adjustments throughout the process, only single-stage treatment as compared to compulsory two stage treatment in Masquelet technique. When performing a bone transport the reconstructed bone is a hollow bone, similar to the original bone. The hollow bone is biomechanically better than the bone after using the Masquelet technique. In those cases, usually, a rodlike bone develops. The additional advantage of having no need of bone grafts and no added donor site morbidity gives bone transport an extra edge. However, there are some evidence on animal studies which support better bone healing with concentrated growth factors along with Masquelet technique on a critical bone defect model in rabbit radius but no consensus

Table 3 Comparison of functional results of the present study with document literature in past by ASAMI criteria

S. no.	Literature related to functional results in comparable studies	Excellent (%)	Good (%)	Fair (%)	Poor (%)	Failure
1	Present study Gp I	53.84	38.46	0	7.7	0
	Group II	16.67	50.0	25.0	8.33	0
	Overall	36.0	44 .0	12.0	8.0	0
2	Maini et al.	27	40	10	23	0
3	Chaddha et al.	24	36	16	36	0
4	Yin et al.	40	43	17	0	0
5	Patil et al.	41	41	6	6	6
6	Harshwal et al.	73	16	3	8	0
7	Farmanullah et al.	57	31	7	5	0
8	Ajmera et al.	84	8	8	0	0
9	Tong et al. Gp I (IBT)	15.79	31.58	42.11	10.53	0
	Group II (MT)	40	45	15	0	0

Table 4 Comparison of bone results of the present study with document literature in past by ASAMI criteria

S. no.	Literature related to bone results in comparable studies	Excellent (%)	Good (%)	Fair (%)	Poor (%)
1	Present study Gp I	76.92	15.38	0	7.69
	Gp II	25.0	25.0	0	50.0
	Overall	52.0	20.0	0	28.0
2	Maini et al.	70	10	0	20
3	Chaddha et al.	52	4	0	44
4	Yin et al.	67	23	7	3
5	Patil et al.	41	34	10	15
6	Harshwal et al.	65	24	3	8
7	Farmanullah et al.	57	21	14	8
8	Ajmera et al.	76	12	4	8
9	Tong et al. Gp I (IBT)	36.84	7.37	0.53	5.26
	Gp II (MT)	25	50	20	5

was observed in medical literature on infected bone defect of human limbs.

Results of the present study are relevant for comparison of bone transport and Masquelet technique in infected non-union of tibia only upto 6 cm defects. However, Masquelet technique has shown its efficacy in treating large bone defects of all long bones including tibia, femur, humerus, and forearm [2, 5–7, 16]. Results of the Masquelet technique are independent of length of bone defect [7, 29]. Ten (77%) patients in Gp I had union with a single procedure only as compared to two staged Masquelet technique. The authors are of the opinion that bone transport technique should be preferred in patients with bone loss upto 6 cm. Bone loss of more than 6 cm may be managed with Masquelet technique, vascularized fibular grafting or Ilizarov bone transport technique.

This study had a small sample size and short follow-up as its limitations. We did not perform power analysis to calculate sample size as there is scarcity of literature comparing the two techniques and patients with stringent inclusion criteria of the present study are relatively rare. Longer follow-up with a larger sample size might better analyses the clinico-radiological outcomes of both methods. There was a scarcity of English medical literature which compared different techniques of treatment for infected non-union of tibia with described parameters so comparative evaluation was not extensive. However, the strength of study is its prospective and randomized nature. To the best of our knowledge, the present study is the first prospective randomized study in English literature comparing bone transport and Masquelet technique in infected nonunion of tibia.

Conclusions

Both Ilizarov bone transport and Masquelet technique achieved comparable radiological and functional outcomes in infected gap nonunion of the tibia with bone loss upto 6 cm but the results were more reliable and predictable in the bone transport group. We believe that Ilizarov bone transport technique should be preferred in infected nonunion of the tibia with bone loss upto 6 cm over the Masquelet technique.

Take home message

Ilizarov bone transport technique was found better than Masquelet technique in infected nonunion of the tibia with bone loss upto 6 cm. Bony and functional results were comparable in both the methods but more reliable in the Ilizarov bone transport group.

Author contributions RR chief operating surgeon for most of the surgeries, wrote the manuscript, statistical analysis, conducted the data analysis. PKS assisted most of the surgeries, conducted the data analysis, wrote the manuscript, statistical analysis. JD assisted most of the surgeries, conducted the patient follow-up and record-keeping, edited the manuscript. JW data collection, data analysis, wrote the manuscript. RS conducted the data analysis, edited the manuscript. DB conducted the data analysis, edited the manuscript.

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Declarations

Conflict of interest The authors declared that they have no conflict of interest.

Informed consent Informed and written consent was taken from all the patients for surgical interventions as well as for the study participations. This study was approved by the Institutional Review Board (IRB ID: IEC/Th/18/Ortho/03).

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