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ORIGINAL ARTICLE

Reconstruction of Large Bone Defects Using induced membrane Technique of Masque let.

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ABSTRACT

Background: Management of large bone defects is a challenge for the surgeon and the patient as well, many functional and psychological disabilities results on and must be properly dealt with.
Masquelet technique saves time, easily performed and can give good results in managing large bone defects.

Methods: This is a prospective study in which 20 patients were treated using Masquelet technique for large intercalary bone defect. The recorded outcomes included bone union, residual deformity, infection, healing of soft tissues, returning to previous work, persistent pain, permanent joint contracture and patient satisfaction.

***Results*:** The period of follow up ranged from 2.2 to 4 years with a mean of 3.1 years. The bone defect ranged from 5 to13 cm with a mean of 7.5 cm. Fifteen patients out of 20 had an open fracture. Ilizarov was used in 13 cases, locked plates in 4 cases and an LRS in 3 cases. The interval between the 1st and the 2nd stages ranged from 42 to 84 days with an average of 56 days. Seventeen patients (85%) achieved bone union. The infection had relapsed in 4 patients, one of them with flap failure and 3 cases with insufficient debridement; one case was treated by another debridement using a free vascularized flap, 2 cases were shifted to bone transport technique and the last case ended with amputation.

***Conclusions*:** The Masquelet induced membrane technique was highly effective to achieve bone union especially in femoral cases.

***Keywords*:** Induced membrane; Masquelet; Reconstruction; Intercalary bone defect

INTRODUCTION

The management of large bone defects is a big challenge for all of the surgeon, the patient and the community as well, it needs a skillful decision maker to operate on the case, long time of follow up and hospitalization, a lot of costs, and also results in many functional and psychological disabilities [1,2]. Autologous bone graft is not preferred in large bone defects more than 5 cm [3,4]. Otherwise many options like; distraction histogenesis, vascularized bone grafts, and allografts are available[5,6].

Alain Masquelet in 1986 has proposed a technique for large bone defects reconstruc tion, based on inducing formation of a highly vascular membrane by placing a cement in the bone defect which acts as a foreign body. This membrane acts as an incubator providing growth factors in addition to vascular supply preventing resorption of the bone graft[7,8].Up to 25 cm bone defect can be fixed by this technique[9,10].

Even though the most suitable technique remains debatable, each one has its merits and demerits. Induced membrane technique (IMT) of Masquelet is a promising technique that needs more studies, it has the advantage of minimizing healing time in large intercalary bone defects, and it's also less technically demanding [1,5].

We hypothesize that Masquelet technique is a valuable technique in managing large bone defect as reported in literatures, so the question to be answered is whether the Masquelet technique has good results in management of large bone defects?

AIM OF THE WORK

To evaluate the results of the Masquelet technique in treating large intercalary bone defects functionally and radiologically.

METHODS

The cases included in this study were managed by Masquelet technique from Jan. 2016 to dec. 2019, twenty patients with large bone defects ranging from (5 to 13) cm, resulted either from acute trauma, or after infected bone debridement. all of them were performed at Zagazig University hospitals. With clarification of the follow up period, the initial injury cause, the cement spacer duration between the two stages, the fixation type, the complications, and the bone union, all the data was reported for evaluation.

And patients with small defects ≤ 2 cm were excluded.

The results were assessed using a modified system of El Rosasy from Paley [11] which included the evaluation of bone union, residual deformity, residual leg length discrepancy(LLD), any relapsed infection, healing of soft tissue, pain persistence, permanent joint contracture, satisfaction and return to previous work. The end results were considered satisfactory or not according to these findings.

Written informed consent was obtained from all participants, the study was approved by the research ethical committee of Faculty of Medicine, Zagazig University. The study was done according to The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Surgical technique

The 1st stage starts with debridement of all septic and necrotic bone and soft tissues, then length, rotation and alignment were restored regarding to preoperative templating, then fixation of bone using either internal or external fixator, then the defect was filled by a poly methyl methacrylate cement (PMMA), with or without antibiotic, at last a flap was used in some cases for covering the defect[4, 8, 12].

The 2nd stage done after 6 - 8 weeks after the 1st stage to allow membrane maturation and infection subsidence, by careful dissection through the old incision reaching the membrane, which is longitudinally incised by a sharp blade, then removal of the cement by osteotome, then the resected bone ends are refreshed and the medulla opened to remove all dead bone and to facilitate bone graft integration, then membrane is irrigated to remove any residual debris before it`s filled with small morselized cancellous bone graft. Then closure of the membrane by Vicryl suture[4, 8,12, 13, 14].

Statistical *analysis*

The collected data was coded, analyzed and then imported for analysis into Statistical Package for the Social Sciences (SPSS version 20.0). Chi square test (X2) was used to test difference and association of qualitative variable, T test or Mann Whitney were used to test differences between quantitative independent groups, P value was set at <0.05 for significant results & <0.001 for high significant result.

RESULTS

Follow-up period ranged from 2.2 to 4 years with a mean of 3.1 years, their age was ranged from 10 to 50 years with a mean of 28.5 years, male/female ratio was 17:3. Out of 20 patients 13 have light jobs and 7 were heavy workers, 6 were smokers.

The tibia was the affected bone in 10 cases and the femur was affected in 10 cases. 75% had an open fracture. Size of defect was ranged from 5 to13 cm with a mean of 7.5 cm, and the cement duration was ranged from 42 to 84 days with a mean of 56 days. 13 patients had acute post traumatic bone loss and in 7 patients the defect resulted after debridement of bone in whom the cement was mixed with 2gm of Vancomycin. Regarding the method of fixation; Ilizarov frame was used in 13 cases, locked plate was used in 4 cases and LRS was used in 3 cases. Autogenous ICBG was used in 12 cases, addition of ipsilateral Fibula to ICBG was used in 8 cases.

Six cases needed Gastrocnemius flap, two cases needed free vascularized flap from latissimus dorsi muscle and in one case Gastrocnemius flap was used first then revised with latissimus dorsi flap. Bone union was achieved in 17 patients (85%), 4 cases had residual deformity more than 5°. 3 cases had residual LLD more than 2.5 cm, 4 cases had relapsed infection, 4 cases had moderate or severe pain, and 16 patients had returned back to their previous work, 6 patients had permanent joint contracture ≥ 5°. one case ended with amputation. 16 patients were satisfied with the end results. The unsatisfied group (4 cases) was associated significantly with the defect in the tibia specially in post-traumatic bone defect. Dissatisfaction was significant associated with non-united cases with relapsed infection, residual deformity, residual LLD, soft tissue loss, persistent pain, permanent joint contracture and amputation, as declared in **figures (1-2) and tables (1-3)**

Table 1. Result and outcome distribution among studied group

		N	%
Bone union	Not United	3	15.0
	United	17	85.0
Residual deformity	Less than 5°	16	80.0
	More than 5°	4	20.0
Residual LLD	Less than 2.5 cm	17	85.0
	more than 2.5 cm	3	15.0
Relapsed infection	Bone ± soft tissue infection	4	20.0
	No more infection	16	80.0
Soft tissue healing	No exposed bone	17	85.0
	Soft tissue defect	3	15.0
Persistent pain	Moderate or incapacitated pain	4	20.0
	No or mild pain	16	80.0
Return to previous work	Has to change job	4	20.0
	Yes	16	80.0
Permanent joint contracture	Less than 5°	14	70.0
	More than 5°	6	30.0
	Total	20	100.0

Table 2. Relation of satisfaction with basic demographic and clinical characters

			Satisfied (N=16)	Unsatisfied (N=4)	t/ Mann Whitney/X^2	P
Age / years			27.0±8.56	27.5±12.54	-0.086	0.932
Size of defect			8.31±2.57	8.75±3.77	-0.278	0.784
Duration with spacer			53.62±13.58	52.5±7.0	0.158	0.876
Sex	Female	N	2	1	0.39	0.53
		%	12.5%	25.0%		
	Male	N	14	3		
		%	87.5%	75.0%		
Smoking	No	N	12	2	0.95	0.32
		%	75.0%	50.0%		
	Yes	N	4	2		
		%	25.0%	50.0%		
Heavy work	No	N	11	2	0.49	0.48
		%	68.8%	50.0%		
	Yes	N	5	2		
		%	31.2%	50.0%		
Bone affection	Femur	N	10	0	5.0	0.02*
		%	62.5%	0.0%		
	Tibia	N	6	4		
		%	37.5%	100.0%		
Side	Left	N	5	1	0.06	0.8
		%	31.2%	25.0%		
	Right	N	11	3		
		%	68.8%	75.0%		
Type	Closed	N	4	1	0.0	1.0
		%	25.0%	25.0%		
	Open	N	12	3		
		%	75.0%	75.0%		
Cause defect	Acute traumatic bone loss	N	8	0	7.14	0.02*
		%	50.0%	0.0%		
	After debridement	N	6	1		

			Satisfied (N=16)	Unsatisfied (N=4)	t/ Mann Whitney/X^2	P
	on infected bone	%	37.5%	25.0%		
	Post traumatic	N	2	3		
		%	12.5%	75.0%		
Fixation	ilizarov	N	9	4	2.69	0.26
		%	56.2%	100.0%		
	Locked plate	N	4	0		
		%	25.0%	0.0%		
	Lrs	N	3	0		
		%	18.8%	0.0%		
Source	Auto-genouse	N	10	2	0.2	0.64
		%	62.5%	50.0%		
	No	N	6	2		
		%	37.5%	50.0%		
Skin	Free vascularized flab	N	1	1	7.5	0.058
		%	6.2%	25.0%		
	Gastrocnemius flap then free flap	N	1	0		
		%	6.2%	0.0%		
	Gastrocnemius flap	N	3	3		
		%	18.8%	75.0%		
	No need for flab	N	11	0		
		%	68.8%	0.0%		
Interval	<1week	N	8	1	0.82	0.66
		%	50.0%	25.0%		
	<month	N	3	1		
		%	18.8%	25.0%		
	>month	N	5	2		
		%	31.2%	50.0%		

Table 3 Relation of satisfaction with result and outcome

			Satisfied (N=16)	Unsatisfied (N=4)	X^2	P
Bone union	Not United	N	0	3	14.11	0.00**
		%	0.0%	75.0%		
	United	N	16	1		
		%	100.0%	25.0%		
Residual deformity	Less than 5°	N	15	1	9.45	0.002*
		%	93.8%	25.0%		
	More than 5°	N	1	3		
		%	6.2%	75.0%		
Residual _LLD	Less than 2.5 cm	N	16	1	14.11	0.00**
		%	100.0%	25.0%		
	more than 2.5 cm	N	0	3		
		%	0.0%	75.0%		
Relapsed infection	Bone ± soft tissue infection	N	0	4	20.0	0.00**
		%	0.0%	100.0%		
	No more infection	N	16	0		
		%	100.0%	0.0%		
Soft tissue healing	No exposed bone	N	16	1	14.11	0.00**
		%	100.0%	25.0%		
	Soft tissue defect	N	0	3		
		%	0.0%	75.0%		
Persistent pain	Moderate or incapacitated pain	N	0	4	20.0	0.00**
		%	0.0%	100.0%		
	No or mild pain	N	16	0		

			Satisfied (N=16)	Unsatisfied (N=4)	X^2	P
		%	100.0%	0.0%		
Return to previous work	Has to change job	N	3	1	0.07	0.78
		%	18.8%	25.0%		
	Yes	N	13	3		
		%	81.2%	75.0%		
Permanent joint contracture	Less than 5°	N	14	0	11.66	0.001 **
		%	87.5%	0.0%		
	More than 5°	N	2	4		
		%	12.5%	100.0%		

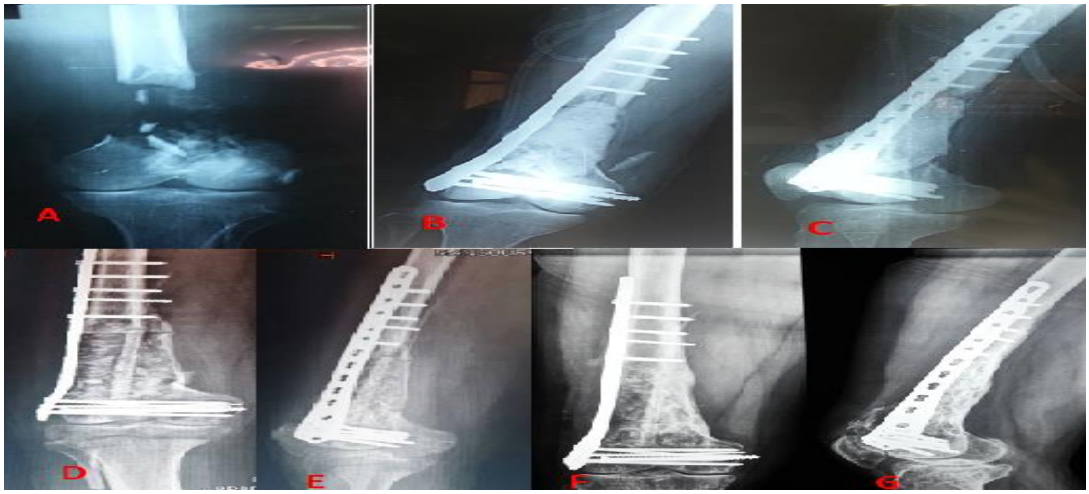

Figure 1. Radiographs of 30 years old male with open G3A supracondylar intercondylar fracture Rt femur. A; At presentation, B, C; After 1st Stage, debridement, fixation with locked plate and placement of cement spacer in the bone defect, D, E; 2 Month after 2nd stage showing cancellous and fibular bone graft filling the defect, F, G; 12 months post 2nd stage with full bony union

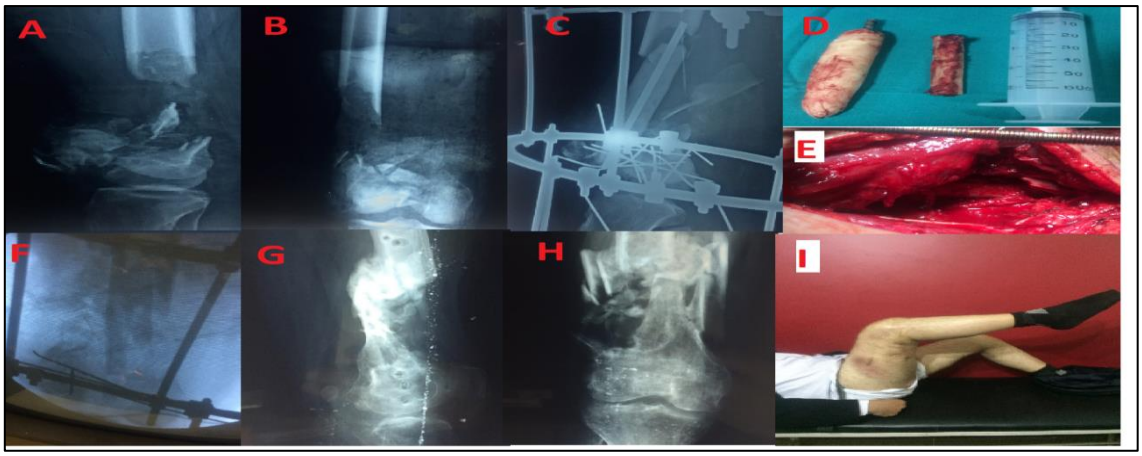

Figure 2. Male patient 32 years old with Gastello type 3b supracondylar intercondylar fracture femur with bone loss. A &B; preoperative x-ray (Lat and AP). C; X-ray after first stage with external fixation and cement spacer. D; intraoperative photo of cement spacer after removal at second stage. E; intraoperative photo during insertion of non-vascularized fibular graft 8 cm long. F; x-ray after second stage with fibular graft insertion. G& H; x-ray after removal of fixator and bone union. I; clinical photo of the patient with knee flexion up to 90°.

DISCUSSION

The large intercalary bone defect is a major task for orthopedic surgeons as it is always accompanied by complicated injuries in the soft tissue, for this the induced membrane technique is good as it provides the bone defect with a periosteal like membrane resembling its formation and characteristics, so it encourages the bone graft incorporation and enhances neo-bone formation. In the current study the bone affected was the femur and tibia equally. A significant relationship was found between the affected bone type and the final outcome, as all

cases of femoral defect united meanwhile all the non-united cases (4 cases) were tibial defects, which suggests a relationship with the bulky coverage of the soft tissue, matching with other studies results.

Karger et al. in 2012 reported that all cases with mal-union occurred in the tibia, even with adding an inter tibiofibular bone graft no significant influence was noted in time of union although it`s a highly recommended technique for bone loss of tibia [8].

El Alfy et al.(2015) reported in a case series of 17 patients; 13 tibias (3 of them failed) and 4 femurs (all of them united) [17].

These results were not matched with number of vascular axes theory supposed by Aurégan et al which states that the 3 axes of blood supply surrounding the tibia -anterior, posterior, tibial and peroneal arteries- allow rapid maturation of the membrane in compare to the single medial femoral axis [14].

Regarding the defect`s size; no significant relationship was found between it and the outcome, in the current study it ranged from 5 to 13cm(**Table 2**). In other studies, it ranged from 1.5 to 18 cm [4], and up to 25 cm [10]. Regarding the condition of the soft tissue; 6 cases needed Gastrocnemius flap, two cases needed free vascularized latissimus dorsi flap was used in two cases, and one case needed Gastrocnemius flap then revision with latissimus dorsi flap and, all the cases needed flap were tibia. Apard et al.(2010) in a study of 12 tibias, in 9 of them a free muscle flap was needed, in two cases local muscle flap and in only one case no flap was needed [18], Schöttle et al. (2005) study 6 tibias, a free muscle flap was used in all of them [19]. Karger et al. (2012) study 84 cases and 46 flaps were done, 8 of them failed, and 6 cases required amputation [8]. Wang et al.(2016) study of 20 tibias, and 12 femurs, 5 tibia required skin coverage with a flap [14].

Bone union in the current study was achieved in in 17 patients (85%), out of 20 cases, matching with the percentage in other studies; 80% up to 100%. [8] but in tibia pure studies the percentage descends to 40% [20].

Ilizarov was used in 13 cases (65%), locked plate in 4 cases (20%) and LRS in 3 cases (15%) without significant relationship between the type of fixation and patient`s satisfaction.

In the current study infection relapsed in 4 cases (20%), one of them is due to failure of flap and in 3 cases is due to inadequate debridement. one case was treated by repeated debridement using a free vascularized flap of latissimus dorsi after failure of gastrocnemius flap, 2 cases were shifted to bone transport and one case (5%) ended in amputation.

Wang et al in 2016 in a study of 32 cases, infection relapsed in 6 cases and a second debridement was done, and one case needed a 3rd debridement [15], In a study by Apard et al infection relapsed in one patient so shifted to bone transport, and two cases of infection at 8th and 24th week required nail exchange and antibiotics till healing [18], Masquelet et al.(2010) reported recurrence of infection early in 5 cases in between the two stages,four of them were treated with repeated debridement and cement placement and one continued to be chronic osteomyelitis[3].

Moghaddam et al.(2015) reported in a study of 50 patients, infection occurred in 35 cases, 32 healed and 3 cases ended in amputation [21].Moreover, El Rosasy et al.(2019) reported in a study of 23 patients, no recurrence of infection [22].Unsatisfication is significantly associated with tibia defects especially in case of acute post traumatic bone defects; supposed to be due to inadequate bulk of soft tissue coverage of the tibia compared to the femur, which provides good vascular nourishment for membrane`s maturation, as shown in(**Tables 1&3**).

On the contrary to theory of vascular axes` number supposed by Aurégan et al. [14]. Better results were noticed in femur cases and in non-united cases for more comparative studies in the future.

CONCLUSION

Masquelet technique is a good method for management of large intercalary femoral bone defect up to 13 cm, with the advantages of easiness, less technical demands, and short time of healing in cases of large bone defect especially in femur, but with mixed results in tibia defects.

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