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Original article

Management of septic non-union of the tibia by the induced membrane technique. What factors could improve results?

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ABSTRACT

Introduction: Management of septic non-union of the tibia requires debridement and excision of all infected bone and soft tissues. Various surgical techniques have been described to fill the bone defect. The “Induced Membrane” technique, described by A. C. Masquelet in 1986, is a two-step procedure using a PMMA cement spacer around which an induced membrane develops, to be used in the second step as a bone graft holder for the bone graft. The purpose of this study was to assess our clinical and radiological results with this technique in a series managed in our department.

Material and method: Nineteen traumatic septic non-unions of the tibia were included in a retrospective single-center study between November 2007 and November 2014. All patients were followed up clinically and radiologically to assess bone union time. Multivariate analysis was used to identify factors influencing union.

Results: The series comprised 4 women and 14 men (19 legs); mean age was 53.9 years. Vascularized flap transfer was required in 26% of cases before the first stage of treatment. All patients underwent a two-step procedure, with a mean interval of 7.9 weeks. Mean bone defect after the first step was 52.4 mm. The bone graft was harvested from the iliac crest in the majority of cases (18/19). The bone was stabilized with an external fixator, locking plate or plaster cast after the second step. Mean follow-up was 34 months. Bony union rate was 89% (17/19), at a mean 16 months after step 2. Eleven patients underwent one or more (mean 2.1) complementary procedures. Severity of index fracture skin opening was significantly correlated with union time (Gustilo III vs. Gustilo I or II, $p = 0.028$). A trend was found for negative impact of smoking on union ($p = 0.06$). Bone defect size did not correlate with union rate or time.

Discussion: The union rate was acceptable, at 89%, but with longer union time than reported in the literature. Many factors could explain this: lack of rigid fixation after step 2 (in case of plaster cast or external fixator), or failure to cease smoking. The results showed that the induced membrane technique is effective in treating tibial septic non-union, but could be improved by stable fixation after the second step and by cessation of smoking.

Level of evidence: IV, Retrospective study.

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1. Introduction

Onset of septic tibial non-union is a therapeutic challenge that may even lead to amputation. Treatment is difficult and often necessitates several surgical steps. It is agreed that resection must extend to several tissues, including the osteitis zone and macro-

scopically pathological soft tissue, with associated non-union site stabilization and effective antibiotic therapy [1], after multidisciplinary team discussion.

In 1986, Pr. A. C. Masquelet described a 2-step procedure called the induced membrane technique, to manage bone defects of varying severity. It consists in filling part of the defect with a cement spacer so as to induce formation of a membrane that will promote subsequent bone graft vascularization [2]. Initial results were highly encouraging. Several further studies have been published [3–9], but there have been few large homogeneous series specific to this technique in septic non-union.

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Our unit has used the induced membrane technique for many years, being convinced of its efficacy. The aim of the present study was to analyze our results in the treatment of septic tibial non-union.

2. Material and method

2.1. Patient selection and inclusion criteria

After local review board approval, we recruited all patients with septic tibial non-union managed in our university hospital department using the induced membrane technique between November 2007 and November 2014. Primary fractures had been treated in our own department or in other centers, or were referred to our department for septic tibial non-union. Data were collected retrospectively from clinical and radiologic files and by telephone contact with the patient. Patients with less than 1 year's follow-up after step 2 of the procedure were excluded, as were cases of aseptic non-union or oncologic bone defect.

Between 2007 and 2014, 21 patients with septic tibial non-union were treated by induced membrane in our department. Three were excluded: 1 died from a defenestration fall after step 1, and 2 were lost to follow-up. The series thus comprised 18 patients for 19 legs: 4 female, 14 male; mean age, 53.9 ± 16.7 years (Table 1).

74% of initial fractures were open (14/19), and all involved both bones. Five patients (26%) had covering flaps (3 medial gastrocnemius, 2 fasciocutaneous) over an exposed site thought to be aseptic before treatment of the septic non-union. Mean time to step 1 was 15.5 ± 20.3 months (range, 8–95 months). Prior to step 1, a mean 3.6 surgical procedures had been performed.

2.2. Study data

Demographic data and medical history were recorded, along with alcohol abuse and smoking status. Following step 1, the

bacteria were studied and antibiotic therapy initiated. Bone defect size after resection was recorded. Following step 2, stabilization method, type of bone graft, time to union and any surgical revision were recorded.

Patients were followed up, with radiologic images comprising 2 perpendicular views of the affected segment. Union was defined by 2 continuous cortices on 2 views. WOMAC functional score [10] was assessed at last follow-up by telephone.

2.3. Surgical technique

The induced membrane technique for septic tibial non-union comprised of 2 steps at 6–8 weeks' interval [2,5,11]:

- step 1 consisted in removing remaining fixation material and debridement with resection of macroscopically infected tissue, taking at least 3 bacteriological samples. Unlike in the princeps technique, we used an antibiotic-loaded cement spacer (polymethyl-methacrylate + gentamicin) in the defect to induce a pseudosynovial membrane. The spacer was positioned as close as possible to the fibula to be consolidated or stabilized. Stabilization after step 1 used an external fixator or plaster cast. Adapted antibiotic therapy was initiated awaiting step 2, after multidisciplinary concertation;
- step 2 consisted in incising the induced membrane with a cold blade, removing the spacer, and filling the defect with a bone graft (autograft from the iliac crest, with or without allograft) after re-permeabilizing the shafts and taking further bacteriological samples. The membrane was then sutured to the surrounding soft tissue around the graft and the site was stabilized by locking plate or external fixator (or plaster cast in case of technical unfeasibility).

Table 1
Patient characteristics and union time.

Patient	Gender/Age	History	Initial fracture	Defect size (mm)	Type of graft	Type of fixation at step 2	Union without complementary procedure/months	Union with complementary procedure (n)/months
ND	F/67		Inf ¼ tibia, closed	84.6	CaIC + AL	Locking plate	Yes/7	N/A
DL	F/65	Osteoporosis	Sup ¼ tibia, closed	27	CaIC + AL	Locking plate	Yes/4	N/A
DD	M/62	VI, CA	Tibial pylon, GII	57.8	CaIC	EF	Yes/10	N/A
TS	F/88	RA	Inf ½ tibia, closed		CaIC	Locking plate	Yes/17	N/A
KD	M/72		Tibial pylon, GI	61.9	CaIC + AL	Plaster cast	Yes/4	N/A
HD	M/24	Smoker	Inf ½ tibia, GI	38.8	CaIC + AL	Locking plate	Yes/5	N/A
DY	F/78		Inf ¼ tibia, GII	46.2	CoIC + AL	Locking plate	Yes/6	N/A
JC	M/52		Inf ¼ tibia, GII	63.5	CaIC + BH	Plaster cast	Yes/32	N/A
BC	M/47	Severe obesity	Bi-focal tibia (sup and mid-thirds), GIIIb	180	CaIC + BH	EF	No	Yes (3)/26
RA	M/32	Smoker	Bi-focal tibia (inf and mid-thirds), GIIIb	26	CaIC	Plaster cast	No	Yes (1)/20
LC	M/52	Smoker	Tibial pylon, GI	50.1	CaIC	Locking plate	No	Yes (1)/17
GY	M/64	Diabetes	Inf ¼ tibia, GIIIa	23.4	CaIC + AL	Locking plate	No	Yes (1)/10
LB	M/49	Smoker	Inf ¼ tibia, closed	41.3	CaIC	Locking plate	No	Yes (1)/16
HT	M/39	Smoker	Bi-focal tibia (inf and mid-thirds), GII	95.2	CaIC	EF	No	Yes (2)/27
VG	M/49	Smoker	Tri-focal tibia, GIIIb	33.9	CaIC	Plaster cast	No	Yes (3)/36
RE	M/50	Diabetes	Inf ¼ tibia, closed	67.5	CaIC	Plaster cast	No	No
VD right	M/34	Smoker, CA	Mid ½ tibia, GIIIb	20	CoIC	EF	No	No
VD left	M/34	Smoker, CA	Mid ½ tibia, GIIIb	20	CoIC	EF	No	Yes (3)/33
MS	M/49	Diabetes, dialysis, arteriopathy	Inf ¼ tibia, closed	11.4	BH	EF	No	Yes (3)/21

VI: venous insufficiency; CA: chronic alcoholism; RA: rheumatoid arthritis; G: Gustilo classification; EF: external fixator; CaIC: cancellous iliac crest; CoIC: cortical iliac crest; BH: bone bank femoral head; AL: allograft; N/A non-applicable.

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