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Original article

Secondary nailing after external fixation for tibial shaft fracture: Risk factors for union and infection. A 55 case series



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ABSTRACT

Introduction: Secondary intramedullary nailing (SIN) following external fixation (EF) of tibial shaft fracture is controversial, notably due to the infection risk, which is not precisely known. The present study therefore analysed a continuous series of tibial shaft SIN, to determine (1) infection and union rates, and (2) whether 1-stage SIN associated to EF ablation increased the risk of infection.

Hypothesis: Factors exist for union and onset of infection following tibial shaft SIN.

Materials and methods: A retrospective series of SIN performed between 1998 and 2012 in over 16-year-old patients with non-pathologic tibial shaft fracture was analysed. EF pin site infection was an exclusion criterion. Fractures were graded according to AO and Gustilo classifications. Study parameters were: time to SIN, 1- versus 2-stage procedure, bacteriologic results on reaming product, post-nailing onset of infection, and time to union.

Results: Fifty-five patients (55 fractures) were included. There were 16 closed and 39 open fractures: 7 Gustilo type I, 26 type II and 6 type IIIA; 33 AO type A, 14 type B and 8 type C. Mean time to SIN was 9 ± 9.6 weeks (range, 4 days to 12 months). There were 23 1-stage procedures, and 32 two-stage procedures with a mean 12-day interval (range, 4–30 days). Twelve reaming samples were biologically positive without secondary infection. There were 4 septic complications (3 abscesses, 1 osteomyelitis), and 1 aseptic non-union required re-nailing. The union rate was 96%. The sole factor of poor prognosis was severity of fracture opening. One-stage SIN did not increase infection risk.

Discussion: The present results were better than reported in the literature, where the rates of Gustilo IIIA and IIIB fracture and pin site infection are, however, higher. Tibial shaft SIN is a reliable procedure, with infection risk correlating with Gustilo type and time to surgery. Surgery should be early, before onset of EF pin site infection. A 1-stage attitude appears feasible in early SIN.

Level of evidence: Level IV. Retrospective study type.

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1. Introduction

Secondary intramedullary nailing (SIN) of tibial shaft fracture after external fixation (EF) is controversial due to infection risk, which can be as high as 44% [1]. On the other hand, isolated EF management is also problematic, with non-union rates ranging between 10% [2,3] and 41% [4]. SIN provides intramedullary input of cancellous tissue at the fracture site during reaming and nailing. It also improves patient comfort (healing care, ankle rehabilitation) and may enable earlier return to work, if sedentary. It may be performed early (within 2 months of fracture), after a “damage control” phase, or later with a view to facilitating fusion. It remains a subject

of debate, with varying reported rates of fusion and of infection. The present continuous retrospective series was therefore analysed to determine:

- fusion and of infection rates, and;
- whether performing SIN as a 1-stage procedure associated to EF ablation increased the risk of infection. The study hypothesis was that factors exist for healing and onset of infection following tibial shaft SIN.

2. Patients and methods

2.1. Patients

A retrospective continuous series of files from 1998 to 2012 was analysed. Exclusion criteria were: age under 16 years, fracture

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on pathologic (tumour) or infected bone (osteitis), and EF pin site infection. Inclusion criteria were: tibial shaft fracture with primary EF and SIN. CRP levels at the time of nailing were required to be < 5 mg/L.

EF ablation and SIN were performed either as 1- or as 2-stage procedures, in the latter case with provisional lower limb immobilization in a posterior splint. In case of 2-stage procedure, the indication was sought and the interval calculated. SIN was deemed early if performed within 2 months. Bacteriology samples were taken from the SIN reaming product.

2.2. Assessment

The interval between EF ablation and SIN was calculated. Any surgical approach to the fracture site during SIN was noted, as were procedures to promote fusion. Age at trauma, gender, trauma mechanism and any associated lesions were recorded. Fractures were graded according to the AO [5] and Gustilo and Anderson classifications [6]. The indications for primary EF (bone, local or general criteria) and for soft tissue coverage surgery were sought.

In post-SIN course, deep infection (abscess, osteomyelitis, etc.) according to Dellinger's criteria [7] and procedures to promote fusion were noted.

The principal assessment criterion at follow-up was fracture consolidation at a minimum of 18 months post-trauma, with consolidation defined as continuity regarding at least 3 of the 4 cortices on AP and lateral radiographs. The tibial axis at fusion was measured on AP and lateral radiographs.

2.3. Statistics

Population homogeneity was assessed on the non-parametric Mann-Whitney test, comparing median ages. The Fisher exact test was used to assess correlations between the various study factors and onset of infection or fusion delay. Statistical analysis used NCSS V6.0 and StatXact V4.0 software. The significance threshold was set at 5%. Results were expressed as mean \pm standard deviation (range) for continuous variables and as percentage (numeric proportion) for categorical variables.

3. Results

Between 1998 and 2012, 55 tibial shaft fractures were managed in 55 patients by emergency EF followed by SIN. All patients showed fusion at follow-up. There were 41 male and 14 female patients; mean age, 39.4 ± 20.7 years (range: 16–83 years). On the AO classification, there were 33 type A, 14 type B and 8 type C fractures; on the Gustilo classification, there were 16 closed fractures, 7 type I open fractures, 27 type II and 6 type IIIA. EF used a HoffmannTM II fixator in 42 cases, a MonotubeTM in 5, a TenxorTM in 2 (all Stryker Trauma, Geneva, Switzerland), and an ExcaliburTM (Orthofix, Verona, Italy) in 6. The indication for primary EF concerned soft tissue issues in 41 cases (severe skin wound in 33 cases, dermal contusion in 3, muscle compartment tension in 5), comminution in 6 cases and associated lesions in 8 (ipsilateral femoral fracture in 2 cases, and multiple trauma in 6). Skin cover, within 7 days of trauma, used thin skin graft in 4 cases and medial gastrocnemial flap in 1 case. There were no local infections related to the EF.

SIN was performed before 2 months in 31 cases and after in 24. Mean fracture-to-SIN interval was 9.2 weeks (range: 2–52 weeks; SD: 9.6 weeks). Only 11 SIN procedures were performed later than 4 months. In 23 cases, SIN was performed in 1-stage following EF ablation; in 32 cases, it was performed in a second stage, at a mean 13 days (range: 4–30 days; SD: 6 days) after EF ablation. The fracture was approached to ease the passage of the reamer guide in 8

cases, systematically associated with > 5 mm fracture site translation or > 8 weeks' post-trauma interval (in 7 of these cases, SIN was performed as a 2-stage procedure).

Intra-operative reaming product samples were positive in 12 cases:

- nine *Staphylococcus epidermidis* (1 initially closed fracture and 8 Gustilo type II);
- one methicillin-resistant *Staphylococcus aureus* (Gustilo type II open fracture with thin skin graft);
- one *Propionibacterium acnes* (Gustilo type I open fracture), and;
- one group G *Streptococcus* (Gustilo type II open fracture).

Adapted antibiotherapy was administered for 6 to 8 weeks. There were no secondary infections, and fusion at end of follow-up was obtained in all cases.

The primary fusion rate was 94.5% ($n = 52/55$). Three patients underwent revision of fixation:

- one nail dynamization (removal of locking screws) at 3 months, achieving fusion by 6 months;
- one hypertrophic aseptic non-union, managed by repeat nailing, achieving fusion within 4 months; and;
- one nail ablation due to osteomyelitis (Gustilo type I open fracture, with negative bacteriology), managed by EF.

At fusion, there were no cases of > 7 malunion.

Fusion was unrelated to early versus late SIN ($P = 0.11$), AO fracture type, EF indication, positive bacteriological findings on reaming product, surgical approach to fracture or infectious complications (Table 1). There was a non-significant trend associating fusion time and severity of skin wound on the Gustilo classification ($P = 0.06$).

There were 4 deep infections (7.2%; 4/55):

- one abscess on distal locking screw (Gustilo type II open fracture, negative bacteriology, 1-stage SIN) managed by surgical drainage and 3 months' antibiotherapy;

Table 1

Time to fusion and significance level (P).

Factors	Fusion > 6months	Significance level (P)
AO fracture type		
A	33/55 (60%)	0.21
B	14/55 (25%)	
C	8/55 (15%)	
Gustilo type		0.06
0	16/55 (29%)	
1	7/55 (12%)	
2	27/55 (49%)	
3	6/55 (10%)	
Initial indication for EF		
Soft tissue	41/55 (74%)	1
Fracture complexity	6/55 (11%)	
Associated lesions	8/55 (15%)	
Time to secondary nailing		0.11
< 2 months	31/55 (56%)	
> 2 months	24/55 (44%)	
Bacterial culture on reaming product		0.57
Positive	12/55 (21%)	
Negative	43/55 (79%)	
Postoperative deep infection		0.20
No	51/55 (92%)	
Yes	4/55 (8%)	

Significance level (P) on Fisher exact test.

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