DISTAL LEG FRACTURES: HOW CRITICAL IS THE FIBULAR FRACTURE AND ITS FIXATION?


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KEYWORDS
Supramalleolar fracture; Distal diaphyseal fracture of the tibia; Fibula fracture; Fibula internal fixation; Intramedullary locked nailing; Locked plate; External fixator

Summary
Introduction: Extra-articular distal tibia fractures include a tibial fracture line located partially or totally in the metaphyseal bone and a fibular fracture in variable areas or sometimes absent. There is no consensus in the literature on the conduct to address the fibula fracture. The main objective of this study was to assess its impact on tibial reduction and union.
Hypothesis: Fibular fixation plays a positive role in reducing tibial displacement and improving mechanical stability of the entire lesion.
Material and methods: This study was based on the multicenter observational group of the 2009 SOFCOT symposium, i.e., 142 metaphyseal fractures of the tibia. The fibula was intact in 10 cases and fractured in 132. In the three main categories of surgical treatment for the tibia (nailing, plating, external fixation) (126 fractures), the fibular lesion was not treated in 79 cases (61%) in this series, nine were treated with intramedullary pinning, and 38 with plate and screw fixation.
Results: There was no statistical relation between the anatomic situation of the diaphysis and the anatomic type of the fibular fracture or between the anatomic type of the fibular fracture and its situation compared to the tibial fracture line. The intertubercular and neck fractures were type A1 or B1 ($P < 0.001$) and were combined to a tibia fracture with a torsional component; the medial-diaphyseal and subtubercular fractures were associated with tibial fracture lines with a simple transversal or comminution or metaphyseal-diaphyseal component ($P < 0.032$).

The rate of pseudarthrosis of the fibular fracture was 4.7% at 1 year; in all these cases, fibular treatment had been conservative. All treatments combined, the tibial axes were statistically better corrected when the fibula was treated with fixation. In four of the 11 cases of axial tibial malunion, the primary fibular fixation caused or worsened them.

Discussion: The present clinical series provides results similar to the biomechanical studies. The consequences of fibular fixation perpetuating a tibia reduction abnormality or on the contrary the absence of fibular fixation appeared as probable factors of residual reduction defects, lack of stability of the tibiofibular complex, and tibia non-union.

Level of evidence: Level IV (prospective cohort study).

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Introduction

Extra-articular fractures of the distal end part of the tibia, also called supramalleolar fractures, were characterized by Gerard and Evrard [1], Zucman and Roux [2], and Utheza et al. [3]. They included a tibial fracture line located partially or totally in metaphyseal cancellous bone and were associated inconsistently with a fibular fracture at different levels. These lesions have recently been the subject of descriptive studies but the fibular fracture was not or was insufficiently integrated [4—6]. However, several biomechanical studies have underscored its importance in overall stability when the tibial fracture was surgically treated with fixation [7—10]. Therefore, surgically intervening on the fibula has not met with consensus, oscillating between conservative management [11,12], quasi-systematic or strongly recommended fixation [13—20], or an eclectic attitude taking into account the anatomic fibular lesions and their reducibility [21—26]. The "competitive" nature of fibular fixation in union of the tibial has even been raised [27,28]. Based on a multicenter series of distal fractures of the leg, this study's main objective was to detail the characteristics of the fibular lesions and study their correlations as well as their impact on reduction and union in terms of the tibial fracture, with the final goal of proposing a therapeutic course of action. This study is all the more important in that publications based on the experience of French teams are rare [6,29,30]. The hypothesis was to show the role played by the fibular lesion in the reduction of the displacement and the mechanical stability of the entire lesion.

Material and methods

This study was based on a multicenter continuous observational series collected from 1/1/2008 to 31/12/2008 in the 2009 French Society of Orthopaedic and Traumatology Surgery (Société française de chirurgie orthopédique et traumatologique [SOFCOT]) symposium: 142 fractures of the distal quarter of the leg in the distal epiphyseal square according to the AO criteria [4] were collected. The diverse aspects of the fibular lesion in both their anatomic and evolving components in the entire tibiofibular lesion were studied based on the AO precepts.

The series

The 142 tibial metaphyseal fractures were broken down into three main types summarized in Fig. 1: 77 A1 fractures, 28 A2, and 37 A3. The fibula was intact in 10 cases and had two fragments in 83 cases, spiral wedge or bending wedge in 30

Figure 1 AO classification [4] of 142 metaphyseal tibial fractures broken down into 77 A1 fractures, 28 A2, and 37 A3. The epiphyseal irradiation, noted (●), was present in 24 cases.
Fibular fracture in distal leg fractures

Table 1  Classification of the 132 fibular fractures in relation to the main AO fracture types [4].

<table>
<thead>
<tr>
<th>AO Type</th>
<th>A1</th>
<th>B1</th>
<th>C1</th>
</tr>
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<tbody>
<tr>
<td>A1</td>
<td>48</td>
<td>12</td>
<td>4</td>
</tr>
<tr>
<td>A2</td>
<td>10</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>A3</td>
<td>25</td>
<td>3</td>
<td>7</td>
</tr>
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</table>

cases, and comminution or bifocal in 19 (Table 1). The fibular diaphysis lesions included 22 intertubercular lesions (16.7%), 66 supratubercular (50%), 14 medial-diaphyseal (10.6%), 10 multifocal (6.6%), and 20 fractures located at the neck of the fibula (15.2%). The fibular lesion was found at the same level as the tibial lesion in 58 cases (44%), proximally in 46 cases (35%), and more distally in 28 cases (21%).

The tibial fractures were treated in 51 cases by intramedullary nailing, in 51 cases with lateral cortex plates, and in 25 cases with external fixation; six tibias received diverse surgical treatments (three transplantar nailing, two tibial screw fixations, and one with isolated fibular pinning), and nine received conservative treatments. In the three main categories of surgical treatment (126 fractures), the fibular lesion was treated conservatively with various methods or with surgical fixation (Table 2). It received no treatment in 79 of the 126 fractures (61%) in this group; the 47 fibular fractures operated were fixed in nine cases using intramedullary pinning and in 38 with plate and screw fixation. Nonsurgical treatment of the fibular fracture was provided in 37 of the 51 nailed tibial fractures (Fig. 2), 16 of the 26 tibial fractures treated with external fixation, and 26 of the 51 tibial fractures treated with plate fixation (Fig. 3).

Method

The leg axes were evaluated immediately after surgery and at the 6th and 12th months in frontal and sagittal views; an angle greater than or equal to 10° defined malunion. The same was true for a rotational abnormality assessed clinically or with CT. The length of the leg bones was compared to the healthy side: a discrepancy was retained if it was greater than 10 mm. The statistical analyses were carried out with SPSS 15.0 for Windows. Associations between qualitative variables were sought using the chi-square test or the Fisher exact test when the theoretical numbers were less than 5.

Table 2  Procedures involving the fibula in relation to the three main surgical fixations for tibia fractures.

<table>
<thead>
<tr>
<th>Tibial osteosynthesis</th>
<th>Fibula not operated</th>
<th>Fibular osteosynthesis</th>
<th>Fibula treated first</th>
</tr>
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<tbody>
<tr>
<td>Fixator n = 25</td>
<td>16 (64%)</td>
<td>5 plates</td>
<td>5</td>
</tr>
<tr>
<td>Nailing n = 51</td>
<td>37 (72.5%)</td>
<td>9 plates</td>
<td>9</td>
</tr>
<tr>
<td>Plate and screw fixation n = 51</td>
<td>26 (51%)</td>
<td>24 plates</td>
<td>1 pin</td>
</tr>
</tbody>
</table>

Figure 2  Example of bifocal distal metaphyseal fracture of the tibia (A). Closed nailing, after fixation of the fibula first: follow-up at 3rd month after proximal unlocking (B). Detail of the union of the metaphyseal fracture (C).
Results

Characterization of the fibular fracture

No statistical relationship was demonstrated between the anatomic location on the diaphysis and the anatomic type of fibular fracture. Similarly, no relation was found between the anatomic type of the fibular fracture and its location in relation to the tibial fracture line. Thirty-six of the 41 intertubercular fractures of the neck were type A1 (spiral twofragment) or B1 (spiral wedge) ($P < 0.001$). In 34 cases, these two types of fibular lesions were found associated with a tibial fracture with a rotational component: A11, A12, A21, and A22 (spiral and simple oblique and wedge, respectively). Finally, 44 of the 70 medial-diaphyseal and supratubercular fractures were associated with tibial fracture lines with a simple or comminution component (A13, A31, and A32) or metaphyseal-diaphyseal component (A23 and A33); the site was systematically significant ($P < 0.032$).

Fibular bone union

Of the 110 fibular fractures followed up radiologically up to the 6th month, 98 showed union; of the 106 evaluated at the 12th month, 101 were considered stable. The rate of pseudarthrosis for the fibular fracture was, respectively, 12.7% and 4.7% at these two follow-up examinations. The five fibular fractures with pseudarthrosis at 1 year of follow-up were then treated with conservative treatment: for four of them, the tibial fracture was stable (one case was lost to follow-up after 12 months, with tibial and fibular pseudarthrosis).

Influence of fibular fixation on the axes

When the fibula was treated with fixation, all tibial fracture treatments combined, the overall postoperative tibial axis ($P < 0.05$), the overall axis at the 6th month ($P < 0.07$), and the overall and frontal axis at the 12th month (respectively, $P < 0.02$ and $P < 0.03$) had improved. Studying these same axes in relation to the surgical treatment applied to the tibial fracture, there was no significant relation in terms of whether or not the fibula was fixed, whereas the tibia was stabilized with a plate or external fixation. On the other hand, when tibial nailing was used, the postoperative overall and frontal axis ($P < 0.006$ and $P < 0.018$), the frontal axis at 6 months ($P < 0.014$), the overall and frontal axis at 12 months ($P < 0.02$ and $P < 0.028$) had improved.

Eleven malunions greater than or equal to $10^\circ$ were observed, six after tibial nailing (three valgus, three recurvatum), four after plate osteosynthesis (two valgus, one recurvatum), and one varus after external fixation (Table 3). The surgical chronology of fibular fixation compared to tibial fixation was analyzed. In the four cases in which the fibula was fixated first (followed in one case by nailing and in three cases by fixation using a tibial plate), this procedure instigated or aggravated tibial malunion. On the other hand, the absence of fibular fixation resulted in tibial malunion (in five cases after nailing, in one after plate fixation, and in one after external fixation).

Length discrepancy

The same procedure was followed for the five cases of length discrepancy greater than 10 mm observed after nailing (shortening) and after four external fixators (two cases of shortening and two of lengthening). The patient with nailing had had fibular fixation first as had one of the patients treated with external fixation; fibular fixation was not provided for the three other patients treated with a fixator.

Tibial union

Seventeen tibial fractures showed pseudarthrosis at 1 year: these union failures were reviewed in relation to the procedure performed on the fibular fracture. The fibula had been surgically fixated in two of the three nailed sites, in two of

Table 3  Tibia fracture malunion angulation greater than or equal to $10^\circ$ after internal fixation: summary of fibular site treatment.

<table>
<thead>
<tr>
<th>Tibial osteosynthesis</th>
<th>Fibula not operated</th>
<th>Fibula with fixation</th>
</tr>
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<tbody>
<tr>
<td>Nailing $n = 6$</td>
<td>$n = 5$</td>
<td>Plate $n = 1$</td>
</tr>
<tr>
<td>Plate $n = 4$</td>
<td>$n = 1$</td>
<td>Plate $n = 3$</td>
</tr>
<tr>
<td>Fixator $n = 1$</td>
<td></td>
<td>Plate $n = 1$</td>
</tr>
</tbody>
</table>
the four plated tibial fractures, and in six of the 10 tibial fractures treated with fixation.

Discussion

This observational series gathers the greatest number of distal tibial fractures reported in the literature, making it possible to detail the anatomic specificities of the fibular lesion: the fibula intact in only 7% of the cases, the frequency of the neck lesions (> 15%), and the predominance of the supratubercular fracture. These data are in agreement with the literature (Table 4). This study demonstrates the concordances between the two fracture sites and the probable injury mechanism: intertubercular or fibular neck fractures are associated with lesions with an A11- and A12-, or A22-type rotational component of the tibia. Similarly, the supratubercular or medial-diaphyseal fibular fractures matched identical tibial comminution lesions. The AO classification does not accord great importance to the fibular fracture [4], which only receives an additional descriptive coding. The specific classifications proposed by Robinson et al. [5] and Bonnevialle et al. [6], established retrospectively and without a reliability study, aimed to integrate the fibular lesion within a single trauma entity while according primacy to the tibial fracture.

In diaphyseal fractures of the leg, the fibular fixation provides a variable contribution to stability according to the experimental studies conducted by Gorszyca et al. [7], Morrison et al. [31], and Weber et al. [32]. Kumar et al. [8] studied the impact on overall stability after nailing and concomitant plate fixation of the fibula: this increased the overall rotational stability of the assembly in distal fractures of the leg. Strauss et al. [9] compared fixation of the distal tibia with locked plate or nailing whether or not associated with a fibular fracture. In axial compression, the plate was twice as rigid as the nail; the nail, however, showed better performance in frontal and sagittal inclination. The presence of a fibular fracture at the same level decreases the mechanical performance of both assemblies, in particular with nail fixation. In similar experimental conditions, Morin et al. [10] showed the insignificant contribution of fibular fixation only in stability in torsion associated with a static locked nail. The clinical results recorded in the present study point in the same direction, underscoring that fibular osteosynthesis contributes to reducing the tibial axes after nailing and prevents shortening when external fixation is used. A posteriori evaluation of tibial osteosynthesis has shown that technically imperfect fibular fixation maintained tibial deviation or caused it, and, on the contrary, would probably have improved reduction of the tibial fracture in certain cases. Therefore, anatomic rigid fixation of the fibula is valuable as a complement to stability, increases the quality of the tibial reduction, and thus provides more reliable bone union [21]. However, comminution of the tibial fracture remains the determining factor in the final stability of the osteosynthesis: this point is particularly important in lesions treated with external fixation [33]. In the same way, the complementary stabilization of the fibula does not seem to prevent tibial pseudarthrosis: out of the 17 cases of pseudarthrosis observed, the fibula had been fixed in 10. The beneficial mechanical constraint of the tibial fracture after nailing or external fixation could therefore be limited or even invalidated.

The literature does not show consensus on the type of fibular fixation and even less on the importance of treating the fibular fracture [34]. Beyond systematically not treating the fibula based on trusting the tibial fixation alone or systematic fibular fixation, a more nuanced attitude is based on the anatomy and mechanics of the lesion. When the tibia is repaired with plate fixation, the same type of fibular osteosynthesis is frequently proposed [17–19]: the fibula is approached by a single anterolateral approach passing in contact with the fibula; fixation of the fibula first simplifies fixation of the tibia. Fixation in a sub- or intertubercular fibular that is destabilizing tibiofibular syndesmosis is recommended [4,5,25]. Mosheiff et al. [13] and Nork et al. [24] provide fixation for the fibula first before tibial nailing so as to obtain reduction along the length of the bone as well as both frontal-sagittal and rotational correction of the tibia. In the series in which the tibial fracture was stabilized with an external fixator, the fibula was rarely stabilized with fixation [29,35]. In the present study, the reasons for opting for fibular treatment were not collected and each team was free to follow its indications. A predominance of conservative treatment of the fibula when the tibia was treated with nailing or fixation (74% and 62% of the cases, respectively) was simply noted, whereas fibular fixation accompanied tibial screw and plate fixation for two patients. However, when the decision to osteosynthesize the fibula was made, it was done first, before placing more than half of the external tibial fixators, in nearly 75% of the nailing procedures and plate osteosyntheses. The consequences of fibular fixation prolonging a reduction abnormality in the tibia were emphasized in the retrospective analysis of this series. Similarly, the absence of fibular fixation arose as a probable factor of a reduction defect, insufficient stability of the tibiofibular group, and tibial pseudarthrosis. The statistical analysis of the fractures treated with nailing demonstrated the complementary role played by fibular

### Table 4

<table>
<thead>
<tr>
<th>Authors</th>
<th>Total number of fractures</th>
<th>Fibula intact</th>
<th>Fibular fracture at same level</th>
<th>Fibular fracture proximal</th>
<th>Fibular fracture distal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bonnevialle et al. [6]</td>
<td>38</td>
<td>2</td>
<td>24</td>
<td>9</td>
<td>3</td>
</tr>
<tr>
<td>Robinson et al. [5]</td>
<td>63</td>
<td>5</td>
<td>22</td>
<td>26</td>
<td>8</td>
</tr>
<tr>
<td>Present study</td>
<td>142</td>
<td>10</td>
<td>53</td>
<td>42</td>
<td>25</td>
</tr>
</tbody>
</table>

fixation placed first in cases of inter- or supratubercular fractures.

**Conclusion**

Whereas the series reported in the literature make it impossible to conclude on the need for fibular repair, the biomechanical studies have demonstrated that fixation of the fibula was useful to increase the stability of the tibial fixation. The analysis of this group of patients confirmed the hypothesis postulated by emphasizing the importance of the fibular lesion within a single biomechanical and pathological entity of distal fractures of the tibia. In particular, it confirms the value of double surgical fixation, as a complement to stability but also as assistance to reduction when external fixation or nailing is indicated. In the first, the cutaneous lesions that generally impose this type of stabilization are rarely located laterally: the fibula fixated first returns the original length to the leg bones and a certain degree of frontal-sagittal reduction. In closed nailing procedures, reduction of both tibial and fibular lesions is even more difficult to obtain if treating a torsion injury resulting in a fracture with a rotational component, ensuring fibular osteosynthesis first anatomically reduces any horizontal displacement. These strategies now remain to be validated in a prospective study.

**Conflict of interest statement**

None for all authors.

**References**


