Distal quarter leg fractures fixation: The intramedullary nailing alone option

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KEYWORDS
Distal diaphyseal fracture of the tibia; Intramedullary nailing; Traumatology

Summary
Introduction: Intramedullary (IM) nailing is the classical treatment for diaphyseal fractures of the tibia. Stabilizing fractures of the distal quarter is recognized as being delicate. We report a continuous, multicenter prospective study of distal tibia-fibula fractures treated with anterograde intramedullary nailing.

Hypothesis: The working hypothesis was to identify the problems encountered with IM nailing alone of distal leg fractures.

Patients and methods: From May 2007 to November 2008, 51 fractures in 51 patients (19 females and 32 males; mean age, 46.2 years [range, 17–93 years]) were treated with IM nailing. The fractures were classified according to the association pour l’ostéosynthèse (AO) classification, with most type A1 (29/51). Thirteen fractures presented a distal articular extension treated with screws in five cases. Fixation consisted in intramedullary nailing, reamed in all cases, performed on a standard or orthopaedic surgery table. Nailing was static and distally locked (50/51). The patients were evaluated clinically and radiologically, with AP and lateral images of both legs and the Olerud score.

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Results: We report one death and eight patients lost to follow-up, providing 42 cases to reviewing at 1 year. The bone union rate was 97.6% in a mean 15.7 weeks. Immediately after surgery, 14 axial deviations greater than 5° were observed, mainly valgus, with only one greater than 10°. The absence of fibular fixation was the only identifiable risk factor for appearance of an initial axial deviation as well as fracture instability over time. Two infections were observed and at 6 months four secondary displacements, one of which can be explained by changing the distal locking due to infection. Four dynamizations were performed. No other risk factor was found. The mean Olerud functional score at 12 months was 83.5 points.

Discussion: The clinical results are comparable to those reported in the literature. From a radiological point of view, the rates and times to bone union were identical. However, the rates of malunion were clearly higher. The risk factors for malunion found in the literature are metaphyseal enlargement, fracture comminution, a too distal location of fracture site, young patient age, patient installation on a standard operating table, and technical errors. The absence of supplementary fibular fixation, the subject of debate in the literature, was the only statistically significant point found in the present study. Nailing distal fractures of the leg provides good clinical results. However, with regard to the malunion rates, the technique must be precise and rigorous. We recommend systematic fibular fixation and use of an orthopaedic table.

Level of evidence: Level IV; cohort type prospective study.

Introduction

The reference treatment for fractures of the tibial diaphysis is locking intramedullary nailing [1], although this technique is recognized as being delicate for fractures of the distal quarter of the tibia. Indeed, the long lever arm, metaphyseal enlargement, intra-articular extension, and epiphyseal–metaphyseal fixation problems make reduction and nailing technically difficult [2,3]. Some authors propose osteosynthesis using a plate and screw fixation [4,5].

The objective of this study was to evaluate the problems encountered, attempt to contribute solutions, and assess the clinical repercussions of intramedullary nailing of distal metaphyseal fractures of the tibia in a continuous, multicenter prospective study of 51 fractures. The working hypothesis was that treating these distal tibial fractures with nailing is technically difficult.

Patients and methods

The series

All the traumatic distal metaphyseal fractures of the tibia according to the association pour l’ostéosynthèse (AO) criteria for the epiphyseal square [6], presenting at most a nondisplaced joint extension, treated with anterograde intramedullary nailing were included in the study (Fig. 1). The exclusion criteria were the existence of open growth cartilage, pathological fractures, revisions for failure following another technique, and associated traumatologic lesions, notably of the lower limb, that could risk interfering in the course of the distal fracture of the tibia. This was a continuous, multicenter prospective study (in 11 French cities: Amiens, Besançon, Brest, Créteil, Dunkerque, Le Mans, Nantes, Nîmes, Rouen, Strasbourg, Toulouse) initiated by the French Society for Orthopaedic and Traumatologic Surgery (Société française de chirurgie orthopédique et traumatologique, Sofcot) covering the period between May 2007 and November 2008.

The series comprised 51 patients, 19 females and 32 males with a mean age of 46.2 years (range, 17—93 years) at the time of the accident. The initial injury was a fall at home in 31 cases (60.7%), a traffic accident in 15 cases (29.5%), for the most part two-wheeled vehicles, and five sports accidents (9.8%). The injury was low energy in 30 cases (58.8%) and high energy in 21 cases (41.2%). Eight cases (15.7%) were occupational accidents. Ten fractures were open, with the following Gustillo classification [7]: three G1, three G2, and four G3A. No neurovascular complication or compartment syndrome was observed. The fractures were classified according to the association pour l’ostéosynthèse (AO) classification [6]: 29 cases (57%) were classified A1, 12 cases (23.5%) A2, and 10 cases (19.5%) A3. The initial radiological workup demonstrated 13 simple articular extensions. Finally, a fracture of the fibula was associated in 50 cases.
Surgical technique

The surgical technique involved anterograde intramedullary nailing with reaming. Depending on the operator’s preference, the patient was installed on an orthopaedic surgery table or a standard table.

In this series of 51 fractures, 38 patients (75%) were treated in the first 12 h after injury. All procedures were performed in a single session and none of the fracture sites were opened. The nailing was performed in 20 cases (39%) on an orthopaedic surgery table and in 31 cases (61%) on a standard surgery table. Reduction was obtained using manual traction in 26 cases (51%), 17 (33.5%) with transcalcaneal traction, and eight (15.5%) with primary osteosynthesis of the fibula as the reduction maneuver. The nailing was static in 50 cases (98%) with constant distal locking. This was purely frontal in 38 cases (74.5%), purely sagittal in three cases (6%), and combined in 10 cases (19.5%). The nails were S2/T2 (Stryker®) for 38 (74.5%), Russell Taylor (Smith and Nephew®) for 12 (23.5%), and CentroNail (Orthofix®) for one (2%). Finally, in five patients (9.8%) additional screws were placed to control articular extension (Fig. 2) (one screw in four cases and three screws in one case). No secondary displacement was observed in the cases of articular extension without screw fixation. Of the 50 fibular fractures, 13 were surgically fixed (26%) (nine plates with screws and four with pins). All the open fractures were successfully treated with direct cutaneous suture. No secondary cutaneous treatment was necessary.

Evaluation criteria

The follow-up was radiological and clinical, prospective and continuous over a period of 1 year. Radiological follow-up was performed at 6 months and then both radiological and clinical follow-up took place at 1 year. The radiological analysis consisted in an AP and lateral x-ray of both legs in the standing position, taking the entire bone segment. The clinical assessment was completed by the Olerud and Molander score [8] and return to initial autonomy (Table 1).

The statistical analyses were performed using SPSS 15.0 for Windows. The associations between qualitative variables were sought using the chi-square test or the Fisher exact test when there were fewer than five theoretic cases.

Results

The series

At the follow-up at 1 year, one patient had died and eight patients had been lost to follow-up, thus giving a continuous prospective series comprising 42 patients (82.4%).

Clinical results

The mean Olerud score was 83.2 points (range, 30—100 points). Pain was nonexistent or occasional in 37 cases (88%). Twenty-nine cases (69%) presented dorsal ankle flexion greater than 15° and plantar flexion greater than 30°. The knee was normal in all the patients and no equinus was observed. Thirty-five patients (83%) experienced no hindfoot stiffness. Thirty-seven patients (88%) walked with no assistance. The walking test was greater than 5 km for 27 patients (70%). Finally, limping was absent or slight in 37 cases (88%). Return to identical home activities was possible for 33 patients (78.5%). Two substantial functional alterations were reported, corresponding to malunion greater than 10° in one case and pseudarthrosis in another case.

Radiological results

No limb shortening greater than 1 cm was observed compared to the opposite side. Fourteen assemblies with axial deviations greater than 5° were observed (27.5%), one of which was greater than 10°. These cases defined the

Figure 2  Distal fracture of both bones of the leg with presence of a articular extension treated with additional screw fixation. A: Initial AP x-ray; the secondary fracture is difficult to see. B: Postoperative AP x-ray and lateral x-ray at bone union, with the axis preserved.
Table 1  Olerud and Molander score [8]: graded out of 100, excellent result when 100 points obtained.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Situation</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pain</td>
<td>None</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>When walking on irregular terrain</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>When walking on any outdoor surface</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>When walking indoors</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Constant and severe</td>
<td>0</td>
</tr>
<tr>
<td>2. Stiffness</td>
<td>None</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Stiff</td>
<td>0</td>
</tr>
<tr>
<td>3. Swelling</td>
<td>None</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Only in the evening</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Constant</td>
<td>0</td>
</tr>
<tr>
<td>4. Climbing stairs</td>
<td>Not a problem</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Asymmetrically</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Impossible</td>
<td>0</td>
</tr>
<tr>
<td>5. Running</td>
<td>Possible</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Impossible</td>
<td>0</td>
</tr>
<tr>
<td>6. Jumping</td>
<td>Possible</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Impossible</td>
<td>0</td>
</tr>
<tr>
<td>7. Squatting</td>
<td>Possible</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Impossible</td>
<td>0</td>
</tr>
<tr>
<td>8. Walking assistance</td>
<td>None</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Bandage ankle brace</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Cane or crutch</td>
<td>0</td>
</tr>
<tr>
<td>9. Work or daily life activities</td>
<td>Same as before the accident</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Less intensive</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Adapted work or part time work</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Severe disability</td>
<td>0</td>
</tr>
</tbody>
</table>

“malunion” group, with four cases of valgus, two recurvatum, three external rotations, and five combined deviations (two valgus + recurvatum, three external rotations + valgus) (Fig. 3). The absence of fibular osteosynthesis was the only statistically significant factor found in initial axial deviation, as well as in maintaining reduction over time. The initial postoperative overall and frontal axis at 6 months ($p < 0.014$), overall and frontal axis at 12 months ($p < 0.02$

Figure 3  Distal fracture of both bones of the leg. Example of malunion. A: Initial AP x-ray. B: Immediate postoperative x-ray: malunion, B valgus. Lack of fibula fixation could explain this frontal deviation.
and $p < 0.028$, respectively) were improved when the fibula was fixed.

At 12 months, 42 radiological and clinical files could be analyzed. The bone union rate was 97.6%. The mean time to union was 15.7 weeks (range, 10–3 weeks). In four cases, bone union was assisted with nail dynamization, at a mean 125 days, successfully in all cases. A fibular graft was successfully completed for one case of bone union delay.

Four cases of secondary displacement were observed, two of which worsened an axial deviation, but only one remained greater than 10°. One case can be explained by changing the distal locking system; for the three others, it seems highly probable that the absence of fibular fixation was the cause (three cases out of three). No aggravation of limb shortening was observed.

The mean Olerud score for the “malunion” group was 72.9 points (range, 30–100); it was 87.8 points (range, 40–100) for the axial nail series, with no statistical difference. Statistically, the only clinical factor correlated with malunion was limping ($p < 0.05$).

Complications

We report two deep infections that required two surgical revisions associating lavage and changing the osteosynthesis material. In one case the distal locking nail was changed and in the other case the nail was removed and external fixation placed. This latter case evolved toward septic pseudarthrosis.

Discussion

Distal metaphyseal fractures of the tibia are rare. In a group of 5953 fractures, Court-Brown and Caesar [9] report 0.7% fractures of the distal tibia, i.e., 13% of all their tibial fractures. Fan et al. [10] evaluated distal fractures at 10% of all tibial fractures. This explains the low number of fractures reported in our multicenter prospective series.

Nailing a distal fracture of the leg involves technical limitations that differ from nailing a diaphyseal fracture. In the latter procedure, nailing provides nearly automatic alignment of the fracture as long as nailing is rigorous and effective. Locking the nail in cases of diaphyseal fractures is straightforward with good distal stability in an environment that is beneficial to bone union (preservation of soft tissue and preservation of the hematoma). For distal fractures, treatment is entirely different. Nailing must be even more rigorous and is not necessarily sufficient to obtain reduction, particularly since nailing does not automatically guarantee alignment. The subisthmic situation of the fracture, with substantial metaphyseal enlargement responsible for discordance with the implant diameter, can cause considerable nail mobility [11] and make nailing difficult and unstable.

Distal nailing is required in these cases to ensure the assembly’s stability; the frequent presence of a short distal fragment often makes the positioning of this locking nail difficult. There is consensus in the literature on the need for double distal screw fixation so as to obtain better control of sagittal and frontal as well as horizontal movements by distributing stresses [12–14]. This double screw fixation provides better stability of fixation, notably in axial compression, which corresponds to the postoperative rehabilitation situation. To obtain good primary nail stability, Gorczyca et al. [12] suggested sawing the distal end of the nail to provide the most distal locking possible. This is not currently recommended since screws are now available whose locking hole is very distal. For most authors, obtaining rigid and static nailing requires intact bone over at least 3–4 cm beyond the fracture [12,15]. Bonneville et al. [16] unreservedly propose nailing for distal leg fractures presenting 2–6 cm of cancellous bone above the subchondral bone. In our series, 50 nails were static nails: today’s lockable nail design has made it possible to provide double distal locking. One of the four secondary displacements observed resulted from a change in an infected distal locking system, proving the important mechanical role played by these screws. No other particular problem was reported by the operators.

Fourteen initial axial deviations were observed, showing insufficiently controlled technique. These deviations are found at union, with a 27.5% rate of malunion, well above the rates found in the literature [3,10,16–22]. No particular problems were reported by the operators, however. It is important to emphasize the lack of homogeneity among the operators. All were senior surgeons but with different levels of expertise, since 32 were attending physicians and only 19 were considered “more experienced” (hospital practitioner, professor-hospital practitioner, or assistant professor-hospital practitioner). This is probably a not insignificant explanatory factor in the axial deviations reported herein, given the rarity of these fractures. Obremskey and Medina [21] confirm this. They compared the results of distal leg fracture nailing performed by two groups of orthopaedic surgeons of different levels from a trauma center. The results were better in terms of bone union and axis restoration for level I traumatologists. However, at the last follow-up, the functional results were identical.

As risk factors for reduction defects, the literature reports metaphyseal enlargement, comminution fracture, surgical technique with a poor entry point or improperly positioning the guide (which must be centered on the profile and slightly lateral on the front) and for certain authors, young patient age [14]. The statistical analysis of our results demonstrated only a single significant risk factor: absence of fibular fixation. The type of fracture, patient installation, age, and sex were not correlated with axial deviation.

Different techniques to assist in reducing the fracture have been proposed. Krettek et al. [23] used Poller screws. The principle of these additional screws is to orient the nail, preventing it from going where it should not go by reducing the metaphyseal space. In experimental work, they demonstrated the mechanical advantage of these screws in terms of initial stability of the assembly: the fractures stabilized by two frontal locking screws and one sagittal locking screw presented initial resistance reduced by 57% compared to the same assembly with one Poller screw [24]. The position of these Poller screws at the fracture site is important since these authors report better results for a distance under 8 mm.

The association of a fibular fracture and a distal tibial fracture was frequent in the clinical series reported, which is confirmed by the present series with 50 associated fractures. The appropriate therapy for the fibula is debated. For some authors, fixation should be systematic [3,17,18],
Table 2  Summary of radiological and clinical data from the series reporting nailing of distal tibial fractures.

<table>
<thead>
<tr>
<th>Series</th>
<th>Number of cases</th>
<th>Articular extension</th>
<th>Fibula fracture</th>
<th>Fibula fixation</th>
<th>Union rate (%)</th>
<th>Time to union (weeks)</th>
<th>Secondary act for union</th>
<th>Malunion</th>
<th>Complications</th>
<th>Remaining</th>
<th>Set up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nork et al. [3]</td>
<td>36</td>
<td>10</td>
<td>35</td>
<td>19</td>
<td>100</td>
<td>23 (13–57)</td>
<td>7</td>
<td>3 BG 4 dynamizations</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Fan et al. [10]</td>
<td>20</td>
<td>2</td>
<td>20</td>
<td>5</td>
<td>100</td>
<td>17 (12–28)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Yes Standard</td>
</tr>
<tr>
<td>Bonnevialle et al. [16]</td>
<td>38</td>
<td>0</td>
<td>36</td>
<td>7</td>
<td>87</td>
<td>20 (8–32)</td>
<td>4</td>
<td>3 dynamizations 1 nail change</td>
<td>3</td>
<td>1 sepsis</td>
<td>3</td>
</tr>
<tr>
<td>Megas et al. [17]</td>
<td>18</td>
<td>4</td>
<td>18</td>
<td>n/a</td>
<td>100</td>
<td>16 (12–18)</td>
<td>2</td>
<td>2 dynamizations</td>
<td>4</td>
<td>1 sepsis</td>
<td>0</td>
</tr>
<tr>
<td>Mosheiff et al. [18]</td>
<td>52</td>
<td>20</td>
<td>7</td>
<td>7</td>
<td>96</td>
<td>15 (12–54)</td>
<td>22</td>
<td>22 BG 22 dynamizations</td>
<td>4</td>
<td>1 sepsis</td>
<td>0</td>
</tr>
<tr>
<td>El Ibrahimi et al. [19]</td>
<td>33</td>
<td>3</td>
<td>33</td>
<td>11</td>
<td>100</td>
<td>17.5 (17–26)</td>
<td>5 dynamizations</td>
<td>4</td>
<td>2 sepsis</td>
<td>0</td>
<td>Yes NR</td>
</tr>
<tr>
<td>Robinson et al. [20]</td>
<td>63</td>
<td>7</td>
<td>56</td>
<td>NR</td>
<td>100</td>
<td>16 (10–50)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Yes NR</td>
</tr>
<tr>
<td>Obremskey and Medina [21]</td>
<td>57</td>
<td>n/a</td>
<td>n/a</td>
<td>4</td>
<td>94.8</td>
<td>14.8 (7–52)</td>
<td>3</td>
<td>2 nail changes 1 dynamization + GO</td>
<td>3</td>
<td>1 sepsis</td>
<td>0</td>
</tr>
</tbody>
</table>

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whereas for Varsalona and Liu [25] a fibular fracture should be fixed in presence of a syndesmosis lesion or a destabilized ankle. They explain this policy by the iatrogenic risk involved and the delay in tibial union. This delay in union of the tibial fracture site, in presence of an intact fibula or with fixation, was reported by Teitz et al. [26] to have a 22% frequency, while some successfully performed fibular osteotomy [27,28] and others proposed fibular fixation of the fibula to assist in reducing the length and rotation of the tibial fracture. The fibula plays an important role in the mechanical stability of the ankle during walking. Strauss et al. [29] demonstrated the advantages of an intact or fixed fibula on assembly stability, whether a locking plate or a nail implant was used for the tibia. When the fibula cannot be fixed, the authors even recommend using a locking plate for the tibia, arguing for better initial stability. Kumar et al. [30] observed greater initial stability when the fibula was fixed compared to nailing alone. Initial control of rotation was improved, but no difference was found in compression when load increased. The cadaver study conducted by Morrison et al. [31] drew quite different conclusions: fixation of fibular fractures increased the resistance to axial stresses by a factor of 2.2, whereas resistance in torsion was only slightly modified. Weber et al. [32] demonstrated that the contribution of fibular fixation on tibial stability depended on the type of tibial fixation. They observed a gain in rigidity only in the group with external tibial fixation. Based on a clinical study, Egol et al. [14] argued for fixation of fibular fractures since it provided better initial control of the fracture (three times more secondary defects in the “non-fixed fibula” group), but it maintained reduction over time. This fibular fixation should be performed first. It allows the surgeon to obtain better reduction of the tibial component, rigidify the assembly by increasing its resistance in axial compression, and provide the assembly with stability over time.

Finally, the Complications of Intramedullary Nailing of Weightbearing Bones (Complications de l’Enclouage Centromédullaire des Os Porteurs, CECOP) study (which to our knowledge is the largest series published on nailed tibial fractures) demonstrated the statistically significant protection provided by the use of an orthopaedic surgery table on fracture reduction and the unfavorable aspect of comminuted fractures [33,34].

In view of our results, we recommend primary fixation of the fibula fracture when it is subtubercular, inter-tubercular, as well as supratubercular up to the distal third of the fibula. In addition, we suggest using the orthopaedic surgery table, even if this factor was not statistically significant. Finally, like Megas et al. [17], we recommend fixation of secondary joint fractures before nailing.

Nine series have been published on nailed distal fractures of the leg [3,9,16–22], reporting 332 fractures (Table 2). The mean union rate was 96.7% (87–100%) for a mean 17.7 weeks to bone union. Our results were analogous (97.6% bone union in a mean 15.7 weeks).

The literature reports a frequency of 40 secondary interventions to assist bone union (12.3%), 36 of which were dynamizations. Some authors present high rates, such as Mosheiff et al. [18] with 42% (22/52 cases), and Nork et al. [3] with nearly 20%. They underline the risk factor of metaphyseal comminution. Our series include four dynamization

<table>
<thead>
<tr>
<th>Series</th>
<th>Number of cases</th>
<th>Articular extension</th>
<th>Fibula fixation</th>
<th>Union rate (%)</th>
<th>Time to union (weeks)</th>
<th>Complications</th>
<th>Remaining Set up</th>
<th>Ortho table</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dogra et al. [22]</td>
<td>15</td>
<td>2</td>
<td>n/a</td>
<td>93</td>
<td>20 (12–54)</td>
<td>3 nail breakages, 1 screw breakage</td>
<td>93 (13%)</td>
<td>Yes Ortho table</td>
</tr>
<tr>
<td>Summary</td>
<td>332</td>
<td></td>
<td></td>
<td>96 (87–100%)</td>
<td>17.7 (12–54)</td>
<td>41 (12.3%), 8 BG, 36 dynamizations, 5 combined</td>
<td>8 sepsis (2.5%), 4 mechanical (1.25%)</td>
<td></td>
</tr>
</tbody>
</table>
procedures (7.8%), all of which evolved favorably toward bone union, stressing the value of this minor procedure in cases of slow union.

From a functional point of view, the results reported in the literature are satisfactory. Nork et al. [3] brought out discomfort in different aspects of daily life at the end of the first year, but with improvement over the following 2 years, reaching a level comparable to the general population. El Ibrahimii et al. [19] published a series whose mean Olerud score was 87.9 points. Robinson et al. [20] presented a series with a mean functional result of 89 points (range, 35–100), according to the Olerud score. Our results are in agreement with these series. The only clinical factor correlated with malunion was the presence of limping, with no explanation possible because pain was not correlated with either limping or malunion. The repercussion of malunion ranging from 5° to 10° at 1 year seems inconsequential given the satisfactory functional results.

Conclusion

Locked nailing of metaphyseal fractures, which are reputed to be difficult to treat, provides highly beneficial results. We report a high rate of bone union, a low number of complications, notably infectious, and good-quality functional recuperation. However, the radiological results should call for caution given the number of cases of malunion. The technique requires rigor and precision, notably when installing the patient. It is difficult to provide a response to the appearance of axial deviations. The only statistically significant factor that we have been able to demonstrate is the absence of fibular fixation. We therefore recommend primary fixation of the distal third of the fibula so as to control the length, rotation, and axes. Technical devices such as Poller screws should be familiar to the surgeon.

Conflict of interest

None for all authors.

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