ORIGINAL ARTICLE

Fibular nonunion after closed-wedge high tibial osteotomy

M. Ramanoudjame a,*, E. Vandenbussche a, T. Baring b, N. Solignac a, B. Augereau a, T. Gregory a, b

a Service de chirurgie orthopédique, université Paris-Descartes, hôpital européen Georges-Pompidou, AP–HP, Paris, France
b Department of Mechanical Engineering, Imperial College, London, UK

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KEYWORDS
Gonarthrosis;
Closed-wedge osteotomy;
Fibular nonunion;
Fibular osteotomy;
Fibula

Summary  Closed-wedge valgus high tibial osteotomy (HTO) has been reported to be an effective procedure for the treatment of medial compartment osteoarthritis of the knee. It requires shortening the fibula, for which many techniques have been described. Dislocation of the proximal tibiofibular joint limits the correction angle of the procedure and the osteotomy of the fibular head runs the rare but dramatic risk of common fibular nerve palsy, which is why many surgeons perform the osteotomy more distally at the shaft. However, the potential complications of fibula shaft osteotomy in closed-wedge proximal tibial osteotomy have been poorly reported. The purpose of this study is to accurately define the incidence and risk of fibular complications.

Materials and methods: One hundred and eight patients (59 men, 49 women, 53 ± 10 years old, preoperative varus: 6.7° ± 4°) underwent a closed-wedge HTO with fibular shaft osteotomy between 1999 and 2004. They were followed up prospectively for clinical and radiological evaluation (2 years of follow-up). The main evaluation criterion was the presence of fibular nonunion.

Results: Eighteen knees (16.6%) underwent fibular complications: 15 nonunions were indexed (13.9%); 11 of them (10.1%) required surgical revision. Three knees had nerve injury, with spontaneous recovery for two of them.

Discussion: Fibular nonunion is the most frequent complication, which often leads to revision procedures. Nonunion was correlated to the preoperative body mass index, the obliquity of the osteotomy plane, and the fragmentary contact. No nonunion was reported when the obliquity of the osteotomy plane was above 50° or the fragment contact greater than 50%.

Level of evidence: Level IV, therapeutic study.

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Introduction

High tibial osteotomy is an effective procedure for the treatment of medial compartment osteoarthritis of the knee...
The closed-wedge technique is simple, reproducible [3], and presents a lower risk of losing correction, nonunion, and infection [4,5], the main complications of the medial opening technique. Lateral closing requires shortening the fibula for which a number of techniques have also been described. Dislocation of the proximal tibial-fibular joint limits the correction angle of the closed-wedge and the osteotomy of the fibular head runs the rare but serious risk of common fibular nerve palsy, which is why many surgeons perform the osteotomy more distally at the shaft level [5–7]. These risks have led many surgeons to prefer a fibular shaft osteotomy technique [6–8].

However, to our knowledge, the specific risks of fibular shaft osteotomy in closed-wedge proximal tibial osteotomy have been poorly reported [6,9,10]. The incidence of fibular nonunion has rarely been specifically studied [11]. The objective of this study was to assess the incidence and cause of fibular nonunion after closed-wedge HTO.

Patients and methods

Patients

A retrospective study on 108 closed-wedge HTOs in 97 patients (mean age, 53 ± 10.4 years [range, 29–74 years]) was conducted in our unit between January 1999 and December 2004. The hip-knee angle (HKA) was +173.3° ± 3.7° (range, 157°–180°). The mean preoperative Hospital for Special Surgery (HSS) score [12] was 76.2 ± 7.8 (range, 56–90). The preoperative data are presented in Table 1.

Table 1 Preoperative demographic data.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mean ± SD (range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>53 ± SD 10.4 (29–74)</td>
</tr>
<tr>
<td>Sex</td>
<td>Male, 59 (54.6%); female, 49 (45.4%)</td>
</tr>
<tr>
<td>Side</td>
<td>Right, 55 (50.9%); left, 53 (49.1%)</td>
</tr>
<tr>
<td>Size (cm)</td>
<td>168 ± SD 7.7 (150–184)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>79.8 ± SD 13.9 (45–116)</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>28.03 ± SD 4.6 (17.7–43.2)</td>
</tr>
<tr>
<td>Hospital stay (days)</td>
<td>10.6 ± SD 4.6 (5–27)</td>
</tr>
<tr>
<td>Preoperative HKA angle (°)</td>
<td>6.7 ± SD 3.7 (0–23)</td>
</tr>
</tbody>
</table>

HKA: hip-knee angle.

Postoperative rehabilitation included immediate mobilization of the knee with isometric work on the quadriceps. The patient remained off the knee for 45 days. At the end of this period, total weightbearing was allowed.

Postoperative assessment

The usual radiological follow-up included immediate postoperative AP and lateral X-rays of the leg and a long-leg film at 3 months. All the patients were seen at 6 months and then every 6 months for the 2 years of follow-up with clinical and radiological assessment. The X-rays were analyzed by an independent orthopedist who was not the operator. The main criterion was the presence or absence of nonunion at the fibular site. The patients were classified into the following categories:

- union: union in less than 3 months;
- delayed union: union in 3–12 months;
- nonunion requiring surgical revision: patients who underwent a second surgical intervention between 6 months and 2 years after the initial procedure, and;
- permanent fibular nonunion still present 2 years after the initial surgery. The clinical examination at 2 years postoperative included the evaluation of fibular nerve function and the HSS score.

Other than the union process, several radiological criteria were studied: the fibular osteotomy level calculated by the ratio between the distance from the head of the fibula and the total length of the fibula; the type of osteotomy plane: lateromedial or anteroposterior; the angle of the osteotomy plane with the horizontal line— if the osteotomy was oriented in the coronal plane, the angle between the osteotomy plane and the fibular axis on the lateral leg X-ray was measured; if the osteotomy was oriented in the sagittal plane, the angle was measured on the AP X-ray; the percentage of contact at the fibular osteotomy site (also on the AP or lateral X-ray depending on the osteotomy plane); and the correction resulting from the valgus tibial osteotomy by comparing the pre- and postoperative long-leg films.

Statistical analysis

All the results were analyzed using SPSS 10.0 software with a 5% significance threshold. The relation between the following variables and the onset of fibular pseudarthrosis was analyzed using the chi-square test and different ANOVAs: age at surgery, sex, body mass index (BMI), the degree of tibial correction resulting from the osteotomy, the fibular osteotomy location, the percentage of contact at the osteotomy line, the angle of the line with the horizontal line, the main orientation of the line (lateromedial or anteroposterior), the presence or absence of a comminution, and the osteotomy modality (oscillating saw or chisel).

Results

Postoperative assessment

The mean postoperative HKA angle was 183.1° (SD, 3.9°) with a correction angle of 10.8° (SD, 3.5°).
ratio between the distance from the fibula head to the osteotomy site and the total length of the fibula was 0.6 (SD, 0.09). The fibular osteotomy was in the sagittal plane in 23 cases (21.3%) and in the frontal plane in 85 cases (78.7%). The mean angle of the osteotomy plane was 46° (SD, 17.2°). The percentage of contact between the osteotomy surfaces was on average 53.2% (SD 32.6%).

The mean postoperative HSS score was 89.4 points (SD, 9.2 points) at 2 years of follow-up: the results were excellent in 53.4% (range, 90–100 points), good in 34.1% (range, 80–89 points), fair in 6.8% (range, 70–79 points), and poor in 5.7% of the cases (<70 points).

The results as well as the existence of fibular nonunion are summarized in Table 2. The patients who developed fibular nonunion had an HSS score at 2 years of follow-up ten points lower than the group of patients who experienced bone union earlier.

Complications

Eighteen knees (16.6%) presented a fibular complication: three knees (2.7%) had nerve lesions, two of which resolved spontaneously. One patient had permanent hypoesthesia of the dorsal and plantar aspects of the foot.

Fifteen cases of fibular nonunion (13.8%) were observed, 11 of which (10.1%) required surgical revision (bone graft decortication and plate fixation) performed a mean 9.4 months (range, 6–24 months; SD, 5.8 months) after the first procedure (Table 2). Pain localized in the fibular osteotomy site was the reason for surgical revision. The mean HSS score just before surgical revision was 80.2 points (SD, 18.2 points). All the patients who underwent surgical revision achieved bone union and their pain at the fibular osteotomy site regressed. They were all satisfied with the intervention. Four patients had not achieved union at the fibular site 2 years after the HTO, but in agreement with the surgeon, a second intervention was not indicated.

The occurrence of nonunion was statistically related to preoperative BMI (P = 0.02), reduced obliquity of the osteotomy plane (P = 0.04), and reduced fragment contact between the osteotomy surfaces (P < 0.001) (Table 3). In patients with nonunion, the BMI was 30.5 kg/m² (SD, 5.03) and the osteotomy angle was 37.1° (SD, 14.1°). In patients who demonstrated bone union, the BMI was 27.6 kg/m² (SD, 4.6) and the osteotomy angle was 46.9° (SD, 17.9°). When the fibular osteotomy angle was greater than 50° (17 patients), nonunion was not observed (Fig. 1). The mean contact surface area was 17.4% (SD, 19.6) in the subgroup with fibular nonunion and 59% (SD, 30.4) in the subgroup with fibular union (Fig. 2).

No significant difference was observed on the other criteria between the "union" and "nonunion" groups (Table 3).

![Figure 1](image1.png)

**Figure 1** Factor associated with risk of nonunion: obliquity of fibular osteotomy line. a: fibular nonunion; the obliquity of the fibular osteotomy plane is nearly horizontal; b: the obliquity of the osteotomy plane is high. The fibular osteotomy has achieved union; c: obliquity of the fibular osteotomy plane in the union and nonunion subgroups.

<table>
<thead>
<tr>
<th>Table 2</th>
<th>State of fibular osteotomy site at 2 years and respective Hospital for Special Surgery (HSS) score.</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Union = union in less than 3 months</td>
</tr>
<tr>
<td>Number of cases</td>
<td>65 (60.2%)</td>
</tr>
<tr>
<td>Fibular pain (number of cases)</td>
<td>0</td>
</tr>
<tr>
<td>HSS score at 2 years of follow-up</td>
<td>90.02 [SD, 7.5]</td>
</tr>
</tbody>
</table>
Table 3  Results.

<table>
<thead>
<tr>
<th></th>
<th>Nonunion (15 cases)</th>
<th>Union (93 cases)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>54.3 ± SD 7.9 (range, 39—65.4)</td>
<td>52.6 ± SD 10.8 (range, 29—74)</td>
</tr>
<tr>
<td>Body mass index (BMI) m²/kg</td>
<td>30.5 ± SD 5.03 (range, 18.3—35.5)</td>
<td>27.5 ± SD 4.6 (range, 17.7—43.2)</td>
</tr>
<tr>
<td>Tibial correction angle</td>
<td>11.1 ± SD 4.1 (range, 7’—20’)</td>
<td>10.7 ± SD 3.4 (range, 5’—17.5)</td>
</tr>
<tr>
<td>Fibular osteotomy level (ratio)</td>
<td>0.6 ± SD 0.14 (range, 0.5—0.7)</td>
<td>0.6 ± SD 0.09 (range, 0.3—0.7)</td>
</tr>
<tr>
<td>Use of oscillating saw for osteotomy</td>
<td>73.3% (11/15)</td>
<td>63.4% (59/93)</td>
</tr>
<tr>
<td>Obliquity of osteotomy</td>
<td>37.1 ± SD 14.1 (range, 15’—50’)</td>
<td>46.9 ± SD 17.9 (range, 0’—80’)</td>
</tr>
<tr>
<td>Lateromedial orientation of osteotomy</td>
<td>80% (12/15)</td>
<td>78.5% (73/93)</td>
</tr>
<tr>
<td>Fragment contact</td>
<td>17.4% ± SD 19.6 (range, 0%—50%)</td>
<td>59% ± SD 30.4 (range, 0%—100%)</td>
</tr>
</tbody>
</table>

Figure 2  Factor associated with risk of nonunion. Fragment contact of the fibular osteotomy site. a: no fragment contact on this relatively horizontal osteotomy. This patient developed painful nonunion that was revised surgically. b: very good fragment contact despite the horizontality of the osteotomy line. The osteotomy achieved union. c: percentage of fragment contact at the fibular osteotomy level in the union and nonunion subgroups.

Other complications

Three patients developed compartment syndrome (two cases of anterior and lateral compartment aponeurotomy).

Other complications related to the tibial osteotomy were encountered: one case of excessive tibial valgus requiring surgical correction, three tibial fractures (one surgically revised), and one hematoma.

Discussion

HTO is a reproducible technique [4,16]. In the articles studying the complications of this technique, fibular osteotomy associated with tibial osteotomy is performed at the fibular head [4]. Although rare, the most important complication of fibular head osteotomy is the common fibular nerve lesion. This risk has led a number of surgeons to perform the osteotomy at the diaphyseal level. The literature has few descriptions of complications after diaphyseal fibular osteotomies. Yet our study shows that complications of fibular osteotomy are frequent (16.6%). Nerve lesions are rare (2.7%) and often transitory, with complete resolution within a few weeks. Fibular nonunion is the most frequent complication (13.8%). This implies that the fibular osteotomy technique must be rigorous.

Nerve lesions and choice of fibular osteotomy level

Osteotomy of the fibula head is a frequent source of common fibular nerve lesions. In a study on nerve conduction involving 11 patients, Aydogdu et al. [6] detected three nerve lesions (27%), two of which involved common fibular nerve palsy. They emphasized that many nerve lesions are not diagnosed because nerve conduction tests are not systematically done. This complication is probably underestimated. Aydogdu et al. recommend performing fibular osteotomy at the diaphyseal level. In our study, only one patient developed a common fibular nerve lesion: the osteotomy site was the middle third of the fibula. Fortunately, the injury was transitory, but its occurrence underscores that this complication can occur at any level and not only in the proximal third of the fibula. Common fibular nerve lesions are more frequent and more serious when the osteotomy is carried out in the proximal third [17—19], but the branch innervating the flexor hallucis longus can be injured by a more distal osteotomy.

Nonunion of the fibular osteotomy site

Nerve lesions are fully described in the literature [9,17—20], but the risk of nonunion after a diaphyseal osteotomy is only briefly mentioned [6,9,20]. In the present series, 13.8% of
the fibular osteotomies did not spontaneously achieve union, which is a high rate. These nonunions had an important impact on the clinical results, leading to an approximately 10-point decrease in the HSS score, with pain at the fibular osteotomy site such that a second surgery targeting union was proposed, resulting in pain regression and union in all cases. For Kurosaka et al. [20], the occurrence of fibular nonunion is related to the degree of osteotomy displacement, itself correlated with the extent of the tibial correction.

In the present series, the valgus angle of the tibial osteotomy was not correlated with the occurrence of nonunion. This displacement also caused traction and compression of the surrounding soft tissues, most particularly in the middle and distal thirds of the fibula, where the fibular artery and vein are in close contact with the medial cortex. The nonunion rate is correlated with a high BMI as well as with two technical criteria: obliquity of the osteotomy plane and the contact surface area of the fragments. A large contact surface area (>50%) and substantial obliquity of the osteotomy plane (>50°) are factors promoting fibula bone union. In their technique, Weill and Schneider [21] use intramedullary pin fixation for fibular osteotomy. Unfortunately, this technique limits the sliding of the osteotomized surfaces and therefore the degree of tibial osteotomy correction possible. The absence of muscle interposition is important in obtaining a good fragment contact zone. We therefore recommend discussing internal fixation associated with an autograft from the tibial osteotomy corner for cases in which the contact surface area is less than 50% and/or the obliquity of the osteotomy plane is less than 50°.

The limitations of this retrospective study most particularly involve the evaluation of the contact surface of the osteotomy fragments, which are estimated on X-rays; its precision is therefore probably moderate.

Conclusion

Fibular diaphyseal nonunion is a frequent complication affecting the clinical results of HTO and leading to surgical revision. The nonunion rate is correlated with high preoperative BMI, low obliquity of the osteotomy plane, and a low fragment contact area. No nonunion was reported when the obliquity of the osteotomy plane was greater than 50° or when the fragment contact area was greater than 50%.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

References