
ORIGINAL ARTICLE

Post-traumatic knee osteoarthritis treated by osteotomy only

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KEYWORDS
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Knee

Summary

\textit{Background:} Osteotomies to address lower extremity post-traumatic deformities are more complex than standard osteotomies performed for congenital deformities, standard osteotomies and their outcomes are not well known. We performed a multincentric retrospective study of these cases. We hypothesized that osteotomy without total knee replacement to correct fracture malunion deformities can provide long-term relief from articular pain.

\textit{Patients and methods:} Twenty-eight patients, mean age 46.4 years old, underwent, between 2000 and 2008, osteotomy for post traumatic osteoarthritis which had resulted in intraarticular malunion in six patients and extraarticular malunion in 22 cases. The initial trauma had occurred a mean 17.3 years before. There were 11 valgus and 17 varus deformities. Two osteotomies were performed in the callus to correct intraarticular malunion. The other osteotomies were performed outside the callus: in 25 cases to correct coronal plane deformities (nine tibial, 11 femoral and five tibial and femoral), including nine cases with associated derotation. Osteotomies were performed on the distal femoral metaphysis and the proximal tibia. There was also one case of supramalleolar derotation osteotomy of the tibia. All 28 patients were contacted again for a consultation. There was a postoperative clinical and radiographic follow-up of at least 2 years for all patients despite four lost to follow-up patients. There were 18 patients with Ahlback grade 2 arthritis, nine grade 3 and one grade 4.

\textit{Results:} Two patients with an intraarticular malunion finally underwent revision surgery to receive total knee replacement because of persistent pain. These patients had grade 3 and 4 arthritis respectively and undercorrection persisted in the coronal plane.

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Introduction
The development of arthritis at a distance from an intra- or periarticular knee fracture is frequent [1]. Rasmussen reported a 21% incidence of post-traumatic arthritis a mean 7.3 years after surgery in a series of 192 patients treated for tibial plateau fractures [2]. There is the same risk in fractures of the distal femur, which are rarer, especially if they are intraarticular [3]. These fractures often occur in active young patients, in whom it is preferable to delay total knee replacement surgery. The presence of material in the knee, prior surgery or the presence of post-traumatic stiffness complicates planning. To our knowledge only two studies in the literature have reported the results of a series of osteotomies for post-traumatic knee arthritis. In the series by Demsar [4], 14 patients were followed for between 2 and 7 years with poor results in 43% of cases. More recently Narashima et al. [5] published a series of seven femoral osteotomies with intramedullary nail fixation for post-traumatic knee arthritis with a mean follow-up of 5 years. Union was obtained in a mean 28 months. Results were satisfactory except for one failure requiring total knee replacement revision surgery.

Our study, performed during the French Hip and Knee Society (Société française de la hanche et du genou) symposium (Paris 2009) reporting the results of a retrospective multicentric study including 28 cases of post-traumatic knee arthritis treated by osteotomy with a mean postoperative follow-up of 44 months, should provide a significant contribution to this topic. The goal was to identify the indications for this type of surgery according to the type of malunion and the extent of existing arthritis. The hypothesis was that an osteotomy to correct a malunion deformity could provide long-term pain relief from arthritis.

Patients and methods

Eight French hospital centers participated in collecting this retrospective series of post-traumatic knee arthritis on a femoral and/or tibial malunion, treated by femoral and/or tibial osteotomy. All cases of post-traumatic knee arthritis operated on between January 2000 and January 2008 responding to these inclusion criteria were included in the study. Twenty-eight cases were identified and patients were called for a follow-up visit (19 men and nine women, mean age: 46 years old) (range 19—70) (Table 1). Malunions included 13 tibial malunions, 12 femoral malunions, and three combined femoral and tibial malunions. Six malunions were intraarticular and 22 were extraarticular (Table 2). Most resulted in coronal/AP plane deformities, 11 valgus and 17 varus. Although all of the files did not include a CT scan examination, a rotational abnormality of more than 10° was clinically identified and confirmed on X-ray in 10 cases of extraarticular malunion (Table 3).

Analysis of demographic data according to the site of the malunion (Table 1) shows that patients with intraarticular malunions were significantly younger (P = 0.05). A mean of two surgical interventions had been performed on the knee before osteotomy (range 1—9) and the mean delay between the initial trauma and osteotomy was 17.3 ± 9.1 years (2—41). This interval was significantly shorter for intraarticular malunions (4 ± 2 years compared to 21.2 ± 11 years for extraarticular malunions; P = 0.01).

Initial treatment for femoral fractures included 11 internal fixations (six plates and five endomedullary nailings) and four cases of orthopedic conservative treatment with long-term traction, and for tibial fractures, 11 internal fixations (nine plates and two endomedullary nailings) and five orthopedic conservative treatment (immobilization in a cast).

At osteotomy all cases of knee arthritis were unicompartamental. There were 18 cases of Ahlback grade 2 arthritis [6], nine grade 3 and one grade 4. Angular deviations in absolute values were similar for patients with grade 2 (9 ± 6°) and grade 3 (8 ± 5°) arthritis. The osteotomy was performed on the callus in two cases and included elevation of an intraarticular malunion. The other osteotomies were performed outside the callus: in 25 cases for coronal plane correction (nine tibial, 11 femoral and five combination tibial and femoral) (Fig. 1) including nine cases with simultaneous correction of a rotational abnormality. All osteotomies were performed on the metaphysis, distal for the femur, and proximal for the tibia. Osteotomies of the distal femoral metaphysis corrected coronal plane and rotational defor-
Table 1  The series.

<table>
<thead>
<tr>
<th></th>
<th>IA</th>
<th>M</th>
<th>DM</th>
<th>D</th>
<th>Total series</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>6</td>
<td>9</td>
<td>5</td>
<td>8</td>
<td>28</td>
</tr>
<tr>
<td>Age (years)</td>
<td>38.4</td>
<td>47.7</td>
<td>47.2</td>
<td>51.2</td>
<td>46.4</td>
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<tr>
<td>Interval between the initial trauma and the osteotomy (years)</td>
<td>4</td>
<td>17</td>
<td>21.4</td>
<td>25.8</td>
<td>17.3</td>
</tr>
<tr>
<td>No. of prior surgical procedures</td>
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<td>1</td>
<td>1</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

IA: intraarticular; M: metaphyseal; DM: diaphyseal-metaphyseal; D: diaphyseal.

Table 2  Location of malunion.

<table>
<thead>
<tr>
<th></th>
<th>IA</th>
<th>M</th>
<th>DM</th>
<th>D</th>
<th>Total series</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>6</td>
<td>9</td>
<td>5</td>
<td>8</td>
<td>28</td>
</tr>
<tr>
<td>Location</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tibia</td>
<td>5</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>13</td>
</tr>
<tr>
<td>Femur</td>
<td>1</td>
<td>6</td>
<td>1</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>Femur + Tibia</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

IA: intraarticular; M: metaphyseal; DM: Diaphyseal-metaphyseal; D: Diaphyseal.

Statistical analysis

The Mann-Whitney test for unpaired groups was used to compare quantitative results of the two groups of patients. A $P$-value of less than 0.05 was considered to be significant.

Table 3  Spatial direction of malunions.

<table>
<thead>
<tr>
<th></th>
<th>IA</th>
<th>M</th>
<th>DM</th>
<th>D</th>
<th>Total Series</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spatial location</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Frontal/Coronal</td>
<td>6</td>
<td>9</td>
<td>4</td>
<td>7</td>
<td>26</td>
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<tr>
<td>Sagittal</td>
<td>6</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>Rotational</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>12</td>
<td></td>
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</tbody>
</table>

IA: intraarticular; M: Metaphyseal; DM: diaphyseal-metaphyseal; D: Diaphyseal.

Results

Early revision surgery was necessary in two patients who underwent total knee replacement, and thus osteotomy was considered to be a failure. Malunion was intraarticular in both patients, aged 43 and 58 years old. The first presented with significant residual varus and grade 4 arthritis following a medial split-depression fracture of the tibial plateau. A valgus osteotomy of the tibial metaphysis was unsuccessful and did not correct the angular deformity (obtained HKA correction 175°) so total knee replacement with a rotating hinge constraint had to be performed 8 months after the osteotomy. The second patient presented with residual valgus in a split fracture of the lateral tibial plateau, which had been insufficiently elevated during initial surgery (Fig. 2). There was Ahlback grade 2 lateral arthritis. An intraarticular...
Osteotomy for post-traumatic knee arthritis

Osteotomy was attempted to elevate the entire tuberosity, resulting in good joint congruency but slight persistent valgus (HKA angle 193°). There was significant residual pain, requiring total knee replacement 1 year later.

Four additional complications required specific surgical treatment. Arthroscopic arthrolysis was performed for postoperative stiffness. Early infection was successfully treated by surgical draining and appropriate antibiotic treatment. Two femoral pseudarthroses required surgical revision with decortication and grafts resulting in union in both cases.

Osteotomy improved pain in most cases. The mean pain score improved significantly in the entire group (13.7 preoperatively versus 34.2 at the final follow-up; \( P = 0.03 \)). Pain improved more in extraarticular malunions (22-point gain versus 10-point gain for intraarticular malunions, \( P = 0.04 \)). Mean function also improved significantly from 75.4 preoperatively to 81.1 at the final follow-up, for a mean improvement of 5.7 points whatever the type of malunion (\( P = 0.17 \)). The function and pain scores were not significantly different at the final follow-up between patients with Ahlbach grade 2 and 3 arthritis (follow-up of 3 ± 2 years for grade 2 with a function score of 85 ± 33 and a pain score of 34 ± 17, and follow-up of 3 ± 2 years for grade 3 with a function score of 88 ± 8 and a pain score of 37 ± 12, respectively). Results were excellent in 18 cases, good in five, average in two and poor in three. There was no change in preoperative range of motion with a mean preoperative active extension decreasing from 3° to 2° at the final follow-up, and a mean flexion of 124° which remained unchanged.

After osteotomy the mean preoperative HKA angle of 189° (180°–196°) in 11 valgus malunion deformities had been corrected to 181° postoperatively (177°–187°), for a mean angular correction of 8°. After osteotomy the mean preoperative HKA angle of 171° (158°–175°) in 17 varus malunions had been corrected to 179° postoperatively (168°–183°), or a mean angular correction of 7°.

**Discussion**

When osteotomy was performed on unicompartamental grade 2 or 3 arthritis it significantly relieved pain, delaying the necessity of total knee replacement by several years. This improvement was even more marked in extraarticular malunions, or if the knee joint had never been treated surgically, but was indirectly affected by a coronal deformity or rotational malalignment. At final follow-up in this series the good results in pain could be attributed to the trophic effect of osteotomies and different results depending on the initial stage of osteoarthritis could only be obtained in a long-term study.

The two failures in this study were intraarticular malunions with late stage cartilaginous lesions (grades 3 and 4). The intraarticular osteotomy performed in these cases was a difficult and invasive procedure, even if Marti et al. [9] and Kerkhoffs et al. [10] have reported good long-term results in their studies. The decision must be made between this indication and a metaphyseal osteotomy of the tibia for extraarticular realignment which is less invasive and which gave longer lasting results in the other cases in our series, even if pain relief was less satisfactory.

In fact, it is difficult to draw conclusions about the failures in this study. In the first case there was undercorrection. In the other case, although the osteotomy in the callus seems to have restored joint congruency, it only partially corrected tibiofemoral alignment. This is why it may be necessary to associate osteotomy of the callus with extraarticular osteotomy to obtain durable results in particular for malunion in fractures of the tibial spine or tibial tubercle of the tibial plateau which associate epiphyseal joint malunion with a metaphyseal deformity. Indeed, besides restoring joint congruency, the priority should be to restore tibiofemoral alignment by respecting, in our opinion, the rule of obtaining slight overcorrection in valgus osteotomies and normal correction in varus osteotomies. According to recommendations, three of the deformities in our series were markedly undercorrected (two with varus at 168° and 175° and the other with 187° valgus), four other patients who had initial varus deformities were slightly undercorrected (final HAK 178°) as well as two patients with initial valgus deformities (final HKA, 182 and 183°). While the degree of valgus in our study was similar to that found in primary knee osteoarthritis (9° in our series versus 11.6° for Backstein...
et al. [11] in a series of 40 femoral varus osteotomies, the degree of varus was greater (a mean 9° in our series versus 1.3° for Takeuchi et al. [12] in a series of 57 valgus tibial osteotomies). Combined tibial and femoral osteotomies were necessary when deformities included both bones, and in particular in case of a traumatic deformity on one bone associated with a marked congenital deformity on the other (Fig. 1).

Correction of the femur is generally performed by open osteotomy on the distal metaphysis allowing correction of frontal as well as rotational malalignments. A series of 14 cases of femoral derotation with static interlocking nailing were reported by Stahl et al. [13]. The authors used an endomedullary saw and obtained union in all cases with derotation abnormalities of up to 63°, emphasizing the interest of this closed procedure. When osteotomy is performed on the diaphyseal femur, nail fixation seems to provide better results, even if union takes longer. [5]. In our series, although the open osteotomies were performed on the femoral metaphysis they were complicated by pseudoarthrosis in two cases, when fixation with simple staples was used. Osteotomy of the proximal tibial metaphysis cannot correct frontal plane deformities, while rotational malalignment should be corrected distally in the supramalleolar region [7]. Indeed, high tibial derotations are known to be difficult, with a high rate of complications including fibular paralyses or compartment syndromes [14]. The total rate of complications in this series was similar to that in “conventional” series of tibial (15% for Insall [15]) or femoral (16.3% for Cameron et al. [16]) osteotomies.

In conclusion, after planning based on a three-dimensional preoperative evaluation of the malunion, an osteotomy of the femoral and/or tibial metaphysis that corrects all aspects of the initial deformity can provide good intermediate term results. In our experience an extraarticular osteotomy is preferable, even in intraarticular malunions if there are no major problems of joint congruency. Osteotomy of the metaphysis should be fixed with a plate and screws, or a blade plate, which maintains good contact between the fragments. The best indication is moderate unicompartmental knee arthritis, but in young subjects lasting results can be obtained in later stages even in the presence of complete joint space narrowing. In case of failure, correction of the initial deformity facilitates the total knee replacement procedure.

Conflict of interest statement

No conflicts of interest for any of the authors.

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