Total knee replacement following intra-articular malunion

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KEYWORDS
Intra-articular malunion; Total knee prosthesis; Post-traumatic knee arthritis; Complications; Adult

Summary
Introduction: There is a lack of data on the management of osteoarthritis of the knee associated with intra-articular malunion. The present study sought to analyze and report results of total knee replacement (TKR) in this indication, including complications and technical specificities.

Hypothesis: TKR for osteoarthritis of the knee associated with intra-articular malunion entails an elevated risk of complication, with impaired functional results.

Objectives: To test this hypothesis in a retrospective series of 74 cases of osteoarthritis of the knee associated with intra-articular malunion.

Patients and methods: A multicenter retrospective series collated the records of 74 patients (mean age, 63 ± 14 years) who underwent TKR for post-traumatic osteoarthritis of the knee associated with intra-articular malunion between 2000 and 2008. Mean trauma-to-TKR interval was 21.8 ± 19 years (range 1 to 56 years). Patients were assessed clinically and radiologically at last follow-up, using the Knee Society score as modified by the Western France Orthopedic Society (Société orthopédique de l’Ouest).

Results: At a mean overall follow-up of 4 ± 3 years (range 1 to 9 years), mean knee score improved from 25 ± 12 to 85 ± 7 (P < 0.001) and mean functional score from 52 ± 13 to 66 ± 10 (P = 0.004). Mean flexion gain was 6°: mean preoperative flexion, 104° ± 28° (10° to 150°), vs. 110° ± 19° (20° to 130°) at follow-up. Nineteen patients (26%) had complications, 13 of which were severe and liable to affect the functional result: three extensor system avulsions, four infections, five cases of stiffness and one of instability.

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**Introduction**

Knee joint fractures are liable to be complicated by post-traumatic osteoarthritis, especially in case of incomplete reduction. At 6–22 years’ follow-up, Volpin et al. [1] reported 23% post-traumatic osteoarthritis secondary to knee joint fracture. In a series of 131 tibial plate fractures with a mean 7 years’ follow-up, Honkonen [2] reported a rate of 44%, increasing with age and previous meniscus lesions.

In advanced disabling osteoarthritis of the knee, total knee replacement (TKR) appears to be the only effective attitude. However, there are few reports of series of TKR in osteoarthritis associated with intra-articular malunion. Roffi et al. [3] reported results at a mean 27 months’ follow-up for 17 TKRs, some of which concerned osteoarthritis secondary to extra-articular malunion. Weiss et al. [4], focusing more specifically on TKR for tibial plateau fracture sequelae, reported results for 62 arthroplasties with a mean 4.7 years’ follow-up. Saleh et al. [5] focused their review exclusively on sequelae of surgically managed tibial plateau fractures, with 15 cases and a mean 6.2 years’ follow-up. Gerich et al. [6] reported a retrospective comparison of results for TKR in osteoarthritis secondary to longstanding tibial plateau fracture vs. TKR in primary osteoarthritis of the knee, reviewing 72 TKRs at 30 months’ follow-up. The unanimous conclusion drawn from these studies is that TKR for post-traumatic osteoarthritis secondary to malunion is associated with an elevated rate of complications and poorer functional results than in primary osteoarthritis of the knee.

A symposium of the French Hip and Knee Society (Société française de la hanche et du genou) on post-traumatic osteoarthritis of the knee retrospectively reviewed a series of 72 TKRs for post-traumatic osteoarthritis of the knee associated with intra-articular malunion. The hypothesis was that prosthetic management of intra-articular malunion involves certain specificities. The aim was to assess the results of TKR after intra-articular malunion, and determine the specific complications and technical issues.

**Patients and methods**

**Patients**

In the present retrospective series, 74 patients (40 female, 34 male; 74 knees) underwent TKR for post-traumatic osteoarthritis of the knee associated with intra-articular malunion between 2000 and 2008, in high-volume eight centers in France. In all cases, TKR was indicated because of advanced and disabling nature of the osteoarthritis. Mean age at surgery was 63 ± 14 years (range 20–89 years). Mean body-mass index (BMI) was 26.6 ± 5. Four of the patients had contralateral knee pathology (5%) and 10 (13%) had impaired gait due to associated locomotor system pathology (other weight-bearing joints or spine).

Mean trauma-to-TKR interval was 21.8 ± 19 years (range 1–56 years). Malunion concerned the tibial plateau more often than the inferior extremity of the femur (40 vs. 20 cases) or of the patella (12 cases) (Table 1). Initial management of the fracture was surgical in 68 cases (92%) and non-operative in six (8%). Thirty-nine of the patients that were surgically managed (53%) had been operated on twice. Former history of infection was noted in 11 patients (15%). Frontal laxity exceeding 10-mm was noted in eight cases (10%). Thirty-three patients (44%) had preoperative stiffness: 23 in flexion (flexion less than 90°), eight in extension (flexion contracture more or equal to 20°) and two mixed extension-flexion.

**Surgical technique**

Standard semiconstrained implants were used in 41 cases (55%), revision implants (with stems and augments) in 29 (40%) and hinged implants in four (5%). Most implants were cemented (72/74, 97%). The patella was resurfaced in 60 cases (81%), and knee exposure required anterior tibial tuberosity osteotomy in 13 (18%).

In the eight patients with extension stiffness, soft-tissue release (posterior capsule release) was performed to correct the flexion contracture, associated to increased distal femoral resection in seven cases. Flexion stiffness, on the other hand, required modification of the bone cuts in only a single case (increased tibial slope). Ligament surgery was common: lateral patellar retinaculum release (six cases), three release of one collateral ligament (two medial, one lateral), and one quadriceps arthrolysis according to Judet et al. [7]. In the two cases of mixed stiffness, increased tibial resection was required to open the tibio-femoral gap in extension and flexion.

**Assessment**

Preoperative telemetry and stress X-rays were used to assess the mechanical angle and reducibility of the deformity. In each center, an observer that did not participate in surgery...
performed a clinical and radiological follow-up assessment on AP and lateral knee views, a femoro-patellar incidence and full-length AP view of both lower limbs. Clinical assessment was based on Knee Society knee scores [8], with the function score simplified according to the French Société orthopédique de l’Ouest (SOO) system [9] and radiological analysis on the Knee Society radiography scores [10] completed by analysis of the postoperative mechanical axis.

Statistics

Statistical analysis used SPSS software (version 12; SPSS Inc., Chicago, IL). Series characteristics were described as mean and standard deviation for continuous variables, and as percentage for categorical variables. The clinical SOO knee and function score assessment was analyzed by Student t test, as were changes in lower limb mechanical axis. The significance threshold was set at 5%.

Results

Complete and recent assessment data were available for 59 patients. The other 15 were considered lost to follow-up, not having been seen during the previous 2 years, although they had had a mean follow-up of 12 months (range 6—24 months) and useable records.

Nineteen patients (26%) had complications: three extensor system avulsions (patellar tendon), four infections, six cases of stiffness and one case of instability, one fibular nerve palsy, one clunk syndrome, two hematomas and one wound of the popliteal artery:

1) the extensor system avulsions included two cases of severe preoperative stiffness (flexions of 20° and 30° respectively in multi-operated knees) and one of chronic knee instability due to neurologic quadriceps insufficiency. This last case affected a woman that sustained a supra- and inter-condylar femoral fracture due to a fall, inducing post-traumatic osteoarthritis; after her TKR, she twice tore her patellar tendon during falls when her knee gave way. In all three patients, direct suture was performed. One of them showed 10° extension lag associated with residual flexion stiffness at 20°; one showed 20° extension lag associated with 75° flexion; the third recovered almost complete active extension with 120° flexion;

2) infection included three multi-operated patients: one with severe flexion stiffness (20° preoperatively); infection set in following quadriceps arthrolysis and skin necrosis during rehabilitation; simple lavage and adapted antibioticotherapy cleared the knee, with 90° flexion 2 years after the septic episode. Another infection occurred in a young patient who sustained very damaging trauma with bone-loss in both femoral condyles, initially filled using acrylic spacer covered by a free flap; several infections occurred before and one following TKR, successfully managed by lavage and prolonged antibioticotherapy without the need for implant removal; final flexion was 90°, with satisfactory knee function (climbing up and down stairs without banister). The third infection in a multi-operated knee required one-step implant removal and replacement. A fourth patient showed early infection, treated by arthroscopic lavage, but died in the following year from intercurrent reasons;

3) six patients showed residual flexion stiffness. Five had had severe preoperative stiffness (20°, 30°, 30°, 40° and 50°), with flexion gain of respectively 0°, 45°, 50°, 10° and 20°. The fourth patient thus lost 10° of flexion, but recovered complete extension despite 20° preoperative flexion contracture. A sixth patient had been managed conservatively for supra- and intercondylar femoral fracture; flexion increased from 70° to 85° following TKR. Two of these six patients showed avulsion of the patellar tendon, as already mentioned above, requiring postoperative immobilization, which delayed flexion rehabilitation;

4) one patient required revision for laxity with knee instability; a thicker insert was implanted and the patella resurfaced, achieving improvement without the need for additional surgery;

5) one patient with severe residual valgus knee following displacement of a lateral tibial plateau fracture showed fibular nerve palsy after the TKR; neurolysis was performed the same day, and the palsy regressed completely within a few week;

6) The other complications comprised one case of clunk syndrome, successfully managed by simple excision of the fibrous suprapatellar nucleus, two hematomas managed by revision without further complication, and one popliteal artery wound caused by a cerclage to fix the tibial tuberosity, requiring bypass repair (Fig. 1).

At a mean 4±3 years’ follow-up (range 1—9 years), mean knee score significantly improved from 25±12 preoperatively to 85±7 at follow-up (P<0.001). Mean function score also significantly improved from 52±13 preoperatively to 66±10 at follow-up (P=0.004). The improvement in knee score was significantly greater than in function score. Mean flexion gain was 6°: mean flexion 104°±28° preoperatively (range 10°—150°) vs. 110°±19° (20°—130°) at follow-up. Flexion gain correlated negatively with initial

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Table 1 Location of the malunion and associated deformity regarding lower limb mechanical axis.

<table>
<thead>
<tr>
<th>Location</th>
<th>Isolated axis</th>
<th>Isolated varus</th>
<th>Isolated valgus</th>
<th>Varus + sagittal</th>
<th>Valgus + sagittal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tibial (n=40)</td>
<td>1</td>
<td>12</td>
<td>20</td>
<td>3 (Recurvatum)</td>
<td>4 (Flexion contracture)</td>
</tr>
<tr>
<td>Femoral (n=20)</td>
<td>2</td>
<td>10</td>
<td>5</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Femoral and tibial (n=2)</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Patellar (n=12)</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
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</tr>
</tbody>
</table>
Total knee replacement following intra-articular malunion

Figure 1  A: 75-year-old woman with fracture of both tibial plateau tuberosities. Osteosynthesis induced secondary displacement with generalized osteoarthritis; B: implantation conserved the osteosynthesis plate to situate the joint-line, with tibial component stabilized by a stem; C and D: after a vascular complication requiring revision (popliteal artery wound caused by the cerclage fixing the tibial tuberosity, managed by bypass), evolution was favorable at 36 months: absence of pain, walking with cane, flexion 100° (vs. 90° preoperative); D: the patella was not resurfaced.

flexion ($r = -0.88; P = 0.003$): patients with the poorest preoperative flexion showed higher flexion gains (Fig. 2). Mean extension gain was 5°, with mean preoperative flexion contracture of $6° \pm 8°$ ($0° - 25°$) vs. $1° \pm 3°$ ($0° - 10°$) at follow-up. These results required four manipulations under general anesthesia, including one patient that undergone patellectomy, achieving final flexion of 90°, 100°, 110° and 130° respectively.

Analyzing the results according to malunion location showed the greatest flexion gains in case of femoral malunion, where mean preoperative flexion was poorer than in tibial or patellar malunion (Table 2). Likewise, improvement in pain score was greater in femoral than tibial malunion (Table 2).

In initially valgus knees ($n = 37$), the mean preoperative mechanical axis of the leg (hip-knee angle: HKA)
Discussion

This study involves certain limitations due to its non-controlled, multicenter, retrospective design. Moreover, longer follow-up would be necessary in order to assess the durability of implant fixation. Within these limitations, however, it represents one of the largest series in the literature, confirming the conclusions initially reported.

TKR in this indication remains justified by the significant improvement obtained in knee and function scores, but failed to match that obtained in more classical etiologies of osteoarthritis of the knee associated with constitutional deformity, as demonstrated by Gerich et al. [6]. The complications rate over 20% was also higher than found in classical etiologies, in agreement with former reports. In a series of 62 TKRs for post-traumatic osteoarthritis of the knee, Weiss et al. [4] also reported a 21% revision rate, notably for stiffness or skin or extensor system lesions. Salleh et al. [5] reported three infections and two patellar tendon avulsions in 15 TKRs after arthroscopy secondary to tibial plate fracture malunion.

<table>
<thead>
<tr>
<th>Femoral malunion (FM) n = 20</th>
<th>Tibial malunion (TM) n = 40</th>
<th>Patellar malunion (PM) n = 12</th>
<th>P value (FM vs. TM)</th>
<th>P value (FM vs. TM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preoperative flexion (°) 98 ± 27</td>
<td>104 ± 28</td>
<td>114 ± 15</td>
<td>0.03</td>
<td>0.07</td>
</tr>
<tr>
<td>Flexion gain (°) 18 ± 27</td>
<td>5 ± 20</td>
<td>0 ± 26</td>
<td>0.004</td>
<td>0.4</td>
</tr>
<tr>
<td>Pain score gain 40 ± 14</td>
<td>27 ± 17</td>
<td>35 ± 22</td>
<td>0.9</td>
<td>0.5</td>
</tr>
<tr>
<td>Function score gain 31 ± 27</td>
<td>32 ± 27</td>
<td>25 ± 29</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2 Flexion mobility and pain and function scores in relation to malunion location.

was 191° ± 11° (range 181°–210°) and the mean final HKA 180° ± 3° (175°–184°), and in initially varus knees (n = 37), 173° ± 11° (158°–179°) and 180° ± 3° (174°–188°), respectively. At follow-up, one implant showed signs of aseptic loosening of the standard femoral component in a knee initially operated upon for osteoarthritis resulting from a tibial malunion.

History of osteoarthritis after intra-articular malunion featured initial trauma and associated hemarthrosis and initial treatment, which was frequently surgical or else sometimes non-operative with prolonged immobilization. Such a history has three important consequences: post-traumatic joint fibrosis, induced by hemarthrosis and invasive joint surgery; lower limb misalignment, induced by insufficient reduction or secondary fracture displacement; and cartilage damage induced by the joint fracture, to a varying extent depending on the degree of comminution.

Joint fibrosis complicates implantation, as it involves the soft tissue as a whole: the skin cover, which is deteriorated by multiple previous scars; the synovium adhering to the deep face of the extensor system; and extensor system retraction in case of longstanding stiffness. Firstly, it hinders joint exposure, with a risk of patellar tendon avulsion. In the present series, even though anterior tibial tuberosity osteotomy was performed in 20% of cases, three cases of extensor system avulsion occurred. Secondly, joint fibrosis limits mobility gain, as it is very difficult to treat all of the intra- and extra-articular components of stiffness. Implantation surgery releases the intra-articular adherences and those on the deep side of the extensor system (sub-quadriceps space arthrolysis), but does not treat extensor system retraction. Thus, despite associated bone and ligament surgery, mean joint amplitude gain was moderate (6° in flexion). Thirdly, anterior soft tissue retraction hinders postoperative cicatrization, with a risk of skin necrosis, so that the rehabilitation in flexion has to be limited. And finally, this poorly vascularized cicatrical fibrosis leaves the tissue more liable to infection, as seen from the 5.4% infection rate—much higher than for classical etiologies. For all of these reasons, it is therefore mandatory to inform the patient of the risks involved, and to establish objectives based more of pain relief than on recovery of mobility.

The joint destruction caused by fracture induces misalignment and may require reconstruction of a bone extremity. This entails specific planning. The reducibility of the deformities allows the mechanical axis to be restored without associated osteotomy, whatever the initial deformity in varus or valgus. The deformities are reducible because they are intraligamentary (inside the capsule-ligament envelope), unless there has been capsule retraction on osteophytes. Reducibility should be assessed on X-ray views under forced reduction, which also reveal the status of the collateral ligaments. Views under reduction show the residual deformity, which is usually moderate and can be corrected by bone resection, with release of the collateral ligament located in the concavity of the deformity.

Figure 2 Flexion gain correlated negatively with initial flexion (r = −0.88; P = 0.003): patients with the lowest preoperative flexion showed the greatest gain.
Joint destruction, particularly that of the tibial plateau resulting from a compression fracture, needs to be assessed to know whether it can be included in the bone resection or if a bone defect will remain after the resection planned according to the implant thickness. In the latter case, one must make sure to have reconstruction augments and extension stems available for reconstructing the bone defect. In the present series, this was necessary in 40% of cases.

One final precaution is to check collateral ligament competence in these multi-operated knees. Excessive laxity, especially in the convexity of the axial deformity, may require using an implant with higher constrain. In the youngest patients, semiconstrained implants are preferable, but only if residual laxity after realignment of the knee does not exceed the height of the posterior stabilization cam.

In conclusion, TKR after intra-articular malunion is not straightforward procedure. The present results are in line with the literature, with a high complications rate and particularly the serious risk of extensor system avulsion. Deformity reduction is often easy, but material to fill intra-articular bone loss and ensure joint stability needs to be planned for. In at-risk patients with a long history of surgery, multiple scars and recent infection, caution is needed in restoring flexion. Patient information allows a precise pre-operative contract, focusing on pain symptomatology rather than gain in mobility.

Disclosure of interest

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

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