TECHNICAL NOTE

Computer-navigated revision total knee arthroplasty for failed unicompartmental knee arthroplasty

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KEYWORDS
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Summary The most frequent technical difficulty encountered at unicompartmental knee arthroplasty (UKA) revision to total knee arthroplasty (TKA) is filling in all bone defects. These bone defects can render difficult components positioning, mechanical axis restitution, and ligament balance assessment, which are the three most important parameters for successful TKA. We describe a computer-assisted technique which makes it possible to control these three parameters before removal of the implants that have caused the bone defects. Our study is based on a series of 20 cases, with a minimum follow-up of 2 years. The anatomical and clinical results were very satisfying and comparable to results of primary TKA. We recommend this computer-navigated technique, which is as simple as a primary TKA procedure.

INTRODUCTION

The main technical difficulty encountered during the surgical revision of unicompartmental knee arthroplasty (UKA) by total knee arthroplasty (TKA) is filling bone defects, which are associated with the failed UKA and/or implant removal [1–3]. This bone loss can make it difficult to position the components, to restore the mechanical axis, and to evaluate ligament balance, while these three parameters are essential for good long-term clinical and anatomical TKA results [4,5]. These parameters can be controlled with computer navigation systems, which has been confirmed for primary TKA [4–9], but more rarely for revision TKA [10,11]. We feel that the indication for this technique is especially well adapted to the revision of UKA by TKA, as shown by Confortonier [12], although he did not precisely describe the technique in that paper. This paper provides a technical note based on our experience with computer-assisted revision of UKA by TKA TECHNIQUE®.

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We used the Amplivision® (Amplitude, Valence, France) navigation system. The goal is to control the orthogonal position of the tibial and femoral components in the frontal plane of the mechanical axis, with a mechanical tibiofemoral angle (HKA) of $180° \pm 2°$, to obtain ligament balance in extension and flexion and a patella that is centered in the trochlea.

First step

First step includes building and digitizing the anatomical reference frames (Fig. 1). The initial surgical approach is used again. With a medial approach, the femoral tracker is placed in the incision just above the femoral epiphysis at 45° (at the junction of the anterior and medial surfaces of the femur) to evaluate knee kinematics and flexion balance with the patella reduced. If the lateral approach was taken with medial eversion of the patella, the femoral tracker should be positioned 45° outwards for the same reasons. The tibial tracker is placed outside the incision sufficiently far enough away to allow space for a tibial keel if necessary. Acquisition of anatomical points to build the reference frame and 3D reconstruction of the patient’s knee is performed with the UKA in place. For the femur, care is taken when digitizing the points on the trochlea and the femoral condyle opposite the UKA (Fig. 2). The axis of femoral rotation is identified by the two femoral epicondyles which are easily accessible and orthogonal to the sagittal axis of the femur (center of the femoral head-center of the knee). The frontal plane is determined for the tibia (Fig. 3): we recommend digitizing the tibial surfaces with the implant in place to evaluate the global mechanical axis and ligament balance.

If the implant is removed, the tibial epiphysis is comparable to severe medial osteoarthritis (in case of medial UKA) (Fig. 4).

Second step

The tibial cut can be planned with the implant in place or after it has been removed (Fig. 5). If there is persistent tibial bone loss after the cut, it is filled either with a wedge or a bone graft, and is always associated with a tibial keel, then the cut is confirmed.

Third step

Planning for the femur is performed with the UKA in place and the patella reduced, with a dynamometric extension (Fig. 6), and flexion spacer. Ligament release is performed during this step if necessary. Rotation of the femur is not defined in relation to anatomical references, but in relation to the flexion space and the native trochlea. The mediolateral position of the femoral component is centered in relation to the native trochlea (Figs. 7 and 8). Then the femoral component is removed, the cuts are performed with a 5-in-1 cutting guide and confirmed (Fig. 9). Small femoral bone defects are filled with either cement or bone graft.

Results

This series included 20 cases of failed medial UKA (Table 1). The mean delay to revision of UKA was 4 years and 3 months (3 months — 17 years). The UKA was replaced in all cases by

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**Figure 1** Construction of reference framework: center of knee, of hip, center of ankle. The prosthesis is still in place.
Table 1  Cause of UKA failure.

<table>
<thead>
<tr>
<th>No. of cases</th>
<th>Cause of failure</th>
<th>Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Significant polyethylene wear</td>
<td>9 years, 10 years, 12 years (2 cases)</td>
</tr>
<tr>
<td>2</td>
<td>Fracture/subsidence of the tibial plateau</td>
<td>3 months</td>
</tr>
<tr>
<td>1</td>
<td>Chronic anterior laxity</td>
<td>7 years</td>
</tr>
<tr>
<td>6</td>
<td>Unexplained pain</td>
<td>6 months, 1 year (2 cases), 1.5 years, 3 years, 17 years</td>
</tr>
<tr>
<td>6</td>
<td>Mechanical tibial loosening</td>
<td>10 months, 1 year (3 cases), 1.5 years, 2.5 years</td>
</tr>
<tr>
<td>1</td>
<td>Septic tibial loosening</td>
<td>1 year</td>
</tr>
</tbody>
</table>

Figure 2  Digitizing of femoral points and femoral trochlea.

Figure 3  a: determination of the frontal plane with an axis going through the center of the tibial glenoids and the center of the ankle, taking into account the step angle; b: this axis is easier to determine with the implant in place; c: tibial slope is planned according to the tibial glenoid axis.
Computer-assisted revision of UKA with TKA

Figure 4  a: digitization of tibial points, with components removed; b: tibial planning; c: tibial cut performed.

Figure 5  a: tibial planning; b: control of tibial cut.

primary congruent SCORE® (Amplitude) TKA, with a mobile bearing and without preservation of the cruciate ligaments. The minimum follow-up was 2 years (2–7 years). All of the patients underwent clinical (IKS evaluation) and radiological follow-up (AP and lateral standing radiograph of the knee, with measurement of angle α for tibial varus, angle β for femoral varus, and angle σ for tibial slope, goniometry for measurement of the HKA angle and an axial view of the patella).

Technically the thickness of the polyethylene was 10 mm in 16 cases and 12 mm in four cases. The lateral retinaculum was sectioned in two cases and there was 1–4° external rotation of the femur in 11 cases. A tibial keel was used in nine out of 20 cases. Bone grafts were performed 10 times to fill cavitary defects and in five cases there was a 10 mm medial tibial wedge for segmental bone defects.

The knee score at the final follow-up was 94 points (89–100) and the function score was 90 points (70–100). All patients were satisfied or very satisfied, except one who was disappointed. Mean flexion was 115° (90–140). There were no complications from pins.

Angle α was 89° (89–93°), angle β was 89° (88–91°), tibial slope was 88° (86–91°) and the HKA angle was 179.3° (177–181°). The patella was perfectly aligned 19/20 times.

Discussion

The use of a computer assisted navigation system is of interest for several reasons. Bone cuts and the filling of bone defects can be controlled with navigation, which is not
Figure 6  Femoral planning in extension: control of ligament balance by varus and valgus stress, with the femoral component in place and the patella reduced, while controlling the HKA angle: a: HKA = 179°, asymmetric extension space; b: HKA = 180° balanced ligament. Ligament release is performed if necessary.

Figure 7  Femoral planning in flexion and control of ligament balance, allowing planning of femoral rotation of the component: a: asymmetric ligament balance; b: 2° external femoral rotation and adjustment of ligament balance.
Figure 8  Femoral planning in flexion: alignment of the femoral component in relation to the native trochlea to optimize "alignment of the knee under the patella" 30°, 60°, and 90° of flexion a, b and c.

Figure 9  a: femoral planning: horizontal (rotation), distal, anteroposterior, sagittal (flexum/recurvatum) and frontal (varus/valgus and medial/lateral); b: control of bone cuts.

possible with personalized cut guides or traditional ancillary equipment.

Planning for the femoral component with the navigation technique is based on balancing extension and flexion spaces with dynamometry without an everted patella and the tibial cut is performed with the femoral component of the UKA still in place, which is closer to real clinical function. In fact, in case of medial arthrotomy and lateral patellar eversion, external tibial rotation is increased, and evaluation of the lateral plane of the ligament is less reliable during forced varus/valgus, extension and flexion. While if the femoral component is removed (with traditional ancillary equipment), distal and posterior bone defects make ligament balance in extension and flexion more difficult.

In our practice we do not plan femoral rotation in relation to anatomical references (transepicondyle axis or distal femoral torsion), which would require a preoperative CT
The degree of rotation of the femoral component is dependent upon the flexion space to be balanced and the centering of the trochlear component in relation to the digitized native trochlea, which has not been changed by UKA (Fig. 8). Alignment of the trochlear component is also a compromise between the mediolateral position of the femoral component and femoral rotation. This resulted in good quality femoral alignment in 19/20 cases.

Numerous publications have shown that navigation systems improve implant positioning [4–9,15]. However, Parratte [16] and Bonner [17] have shown that the survival rate of these TKA is not always correlated to the HKA angle. Indeed, we believe that the mechanical axis is only important when ligament balance has been obtained. In the same way the evaluation of ligament balance has real value when the mechanical axis is known. Navigation provides a good compromise for this.

Our intermediate term results are better than those in our series published in 2004 using a traditional procedure [1], and are comparable to those of primary TKA [18], unlike results of other authors [2,19,20]. Like Confalonieri et al. [12], we feel that these good results are due to the use of a navigation system (Fig. 10).

**Disclosure of interest**

FC, JLD, SD, HC, JBH, are members of SCORE group, and developed the TKA SCORE® (Amplitude).

OG: no conflict of interest.

**References**


