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Clinical and technical factors influencing outcomes of unicompartmental knee arthroplasty: Retrospective multicentre study of 944 knees

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KEYWORDS
Unicompartmental knee arthroplasty; Knee osteoarthritis

Summary
Introduction: Unicompartmental knee arthroplasty (UKA) is reserved for osteoarthritis confined to a single femoro-tibial compartment with an intact anterior cruciate ligament. UKA remains controversial. The objective of this retrospective multicentre study in a large sample was to assess the influence of age, sex, body mass index (BMI), patellofemoral involvement, and implant design on functional outcomes and prosthesis survival rates.

Material and methods: Nine hundred and forty-four patients who underwent UKA at centres located in western France between 1988 and 2008 were re-evaluated. The IKS scores and KOOS were determined. Prosthesis survival according to various factors was assessed using the Kaplan-Meier method.

Results: A clinical evaluation was performed in 720 cases after a mean follow-up of 62 months. The IKS function score improved by 23.6 points in men and 17.3 points in women (P=0.007). Ten-year prosthesis survival was 83.7% overall; 79% in women versus 87% in men (P<0.01); and 76.7% in patients younger than 70 years versus 88.3% in those 70 years or over (P<0.01). BMI had no significant influence on prosthesis survival. No significant differences between clinical outcomes or prosthesis survival were found across implant design categories.

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Introduction

Unicompartmental knee arthroplasty (UKA) has restrictive but validated indications: the procedure is reserved for knee osteoarthritis involving a single femoro-tibial compartment with a functioning anterior cruciate ligament (ACL) [1–5]. UKA continues to generate controversy in the orthopaedic community, probably because it raises major technical challenges, with even minimal technical imperfections promptly resulting in early mechanical failure. In European countries, and most notably in France, orthopaedic surgeons have supported the use of UKA, whereas J.N. Insall in the USA described the procedure as hazardous based on his experience with a small number of patients [6]. However, UKA has generated new interest in the USA in recent years [7–11]. Several studies showed faster achievement of final outcomes with good results in terms of pain relief, knee stability, and range of motion compared to total knee arthroplasty (TKA) [12–14]. Prosthesis survival curves have been established in numerous studies based on longitudinal follow-up data for a given implant design [15–27] or on large numbers of patients included in nationwide registers [28–30].

A number of criteria relevant to patient selection for UKA remain debated. Therefore, we retrospectively reviewed the data from a large sample of patients to assess factors associated with outcomes, with emphasis on clinical characteristics.

Material and methods

We conducted a retrospective multicentre study of 944 UKA procedures in 818 patients (126 bilateral procedures, including 31 in a single step). The procedures were performed between 1988 and 2008 by multiple surgeons in 12 private and public university centres in western France.

Characteristics of the study sample

The sample comprised 590 (62%) women and 364 men. Mean age at surgery was 70 ± 9 years (range, 26–93 years) overall, 69.6 ± 8.9 years in men, and 70 ± 9 years in women. The 60- to 80-year age group comprised 73.5% of the sample, the under-60 age group 14.8%, and the over-80 age group 11.7%. Among patients younger than 60 years, 56% were employed and 23% participated in sports activities at the time of the UKA. Mean body weight in the overall sample was 73 ± 12 kg (range, 40–125 kg). Of the 701 patients for whom both body weight and height were available, 198 (24.7%) had body mass index (BMI) values greater than 30 kg/m² and 603 (75.3%) had BMI values lower than 30 kg/m². The diagnosis was primary osteoarthritis in 85.4% of cases, post-traumatic osteoarthritis in 7.2%, and osteoarthritis secondary to osteonecrosis in 7.4%. The ACL was considered deficient at surgery in 43 (5%) knees. The patella was centred in 93% of knees; radiological evidence of patellofemoral osteoarthritis was noted in 13% of cases. Previous surgical procedures on the knee were as follows: meniscectomy, n = 94; osteotomy, n = 34; ACL reconstruction, n = 5; and miscellaneous, n = 6. Of the 944 UKA procedures, 862 (91%) were medial and 82 (9%) lateral.

Overall, the preoperative International Knee Society (IKS) score values were 60 ± 14 for the knee score and 60 ± 19 for the function score. Preoperatively, mean active range of flexion was 122 ± 13° (range, 50–150 °) and mean fixed flexion was 3 ± 5° (range, 0–30 °). The patella was painful in 11.5% of cases. IKS score values differed according to age, sex, and BMI (Table 1).

The implants used were from 30 different companies and included six implants that have been withdrawn from the market (Fig. 1). The most commonly used implants were HLS® (Tornier), Miller-Galante® (Zimmer), Alegreto® (Protek), and Preservation® (DePuy). We used biomechanical features to categorise these implants as follows: (i) condylar cut (455 of 836 cases with available data, 54%) versus condylar resurfacing (381/836, 46%); and (ii) all-polyethylene tibial component (356 cases of 910 with available data, 44%) versus metal-backed tibial component (554/910, 56%; 48 fixed and 506 mobile). Cement was used for all but 14 (4%) implants.

Data collection and analysis

A standardised electronic form was used to collect the following data: IKS knee and function scores before and after UKA; radiological criteria 3 and 6 months postoperatively then at last follow-up; and Knee injury and Osteoarthritis Outcome Score (KOOS) at last follow-up. The KOOS provides a global assessment (symptoms, functional impact on everyday activities and sports activities, and quality of life) of post-traumatic or degenerative knee conditions.

Preoperative data were extracted from the medical records. We assessed the influence of the following variables on UKA outcomes and survival: age, sex, BMI, ACL status, osteoarthritis of the contralateral femoro-tibial compartment, and patellar pain. A separate analysis was performed to assess the potential impact of implant design on clinical outcomes and prosthesis survival.

Prosthesis survival was evaluated using the Kaplan-Meier method. Failure was defined as any re-operation involving all or part of the implant. For statistical comparisons, parametric or non-parametric tests were performed depending on sample size. Values of P lower than 0.05 were considered significant.
Factors affecting outcomes of UKA

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Preoperative IKS function and knee scores (/100).</th>
</tr>
</thead>
<tbody>
<tr>
<td>IKS (available for 927 knees)</td>
<td>&lt; 60 years</td>
</tr>
<tr>
<td>Function</td>
<td>67</td>
</tr>
<tr>
<td>Knee</td>
<td>66</td>
</tr>
<tr>
<td>IKS (available for 944 knees)</td>
<td>Men</td>
</tr>
<tr>
<td>Function</td>
<td>63</td>
</tr>
<tr>
<td>Knee</td>
<td>60</td>
</tr>
<tr>
<td>IKS (available for 801 knees)</td>
<td>BMI &gt; 30 kg/m²</td>
</tr>
<tr>
<td>Function</td>
<td>57</td>
</tr>
<tr>
<td>Knee</td>
<td>59</td>
</tr>
</tbody>
</table>

NC: non significative.

| Figure 1 | Distribution of implants used in our sample of unicompartmental knee arthroplasties performed between 1988 and 2008. |

Results

Mean follow-up was 62 ± 52 months (Fig. 2). A standardised data form was available for each of the 944 procedures and a KOOS questionnaire for 203 procedures. After 50.5 ± 52 months, 137 (14.5%) cases had been lost to follow-up; and after 88 ± 58 months, 88 (9.5%) patients had died. The overall 10-year prosthesis survival rate was 83.7%. The rate of early revision (within 90 days) was 1.7%, the reasons being infection (n = 6, 0.7%), haematoma (n = 7), fracture (n = 3), and skin necrosis (n = 1). None of the factors studied (age, sex, BMI, and osteoarthritis stage) was associated with early complications.

Postoperative IKS score values were 90 ± 11 (vs. 60 ± 14 preoperatively) for the knee score and 82 ± 17 (vs. 60 ± 19 preoperatively) for the function score. Thus, the IKS knee score improved by 30 ± 18 points and the IKS function score by 21 ± 22 points.

Results according to age

Table 2 reports overall results in the three age groups (< 60 years, 60–80 years, and > 80 years). The preoperative IKS knee and function scores were directly related to age: their values decreased as age increased. At last follow-up,
the patient satisfaction rate and IKS knee score were similar across age groups, whereas the postoperative IKS function score was significantly higher in the under-60 group, although improvements in both IKS scores increased with age. KOOS values showed no significant differences across age groups. Prosthesis survival rates were 76.7\% in patients younger than 70 years and 88.3\% in those aged 70 years or over ($P = 0.002$) (Fig. 3).

Results in men and women

Table 3 reports results in men and women. Compared to men, for the postoperative IKS function score, women had a similar absolute value (82 points) but a significantly greater improvement compared to the preoperative value. KOOS values at last follow-up were not different between men and women. Prosthesis survival after 10 years was significantly better in men than in women (87.1\% vs. 79\%; $P < 0.01$) (Fig. 4).

Results according to body mass index

The preoperative IKS function score was better in non-obese patients. At last follow-up, however, IKS score and KOOS values showed no significant differences in the two patient groups defined by BMI values < 30 kg/m$^2$ and $\geq$ 30 kg/m$^2$.
Factors determining patellar involvement

Table 4  Postoperative clinical outcomes according to body mass index (BMI) (data available for 801 knees).

<table>
<thead>
<tr>
<th></th>
<th>BMI &gt; 30 kg/m²</th>
<th>BMI &lt; 30 kg/m²</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>198</td>
<td>603</td>
<td></td>
</tr>
<tr>
<td>Satisfaction</td>
<td>86.5</td>
<td>85</td>
<td>0.81</td>
</tr>
<tr>
<td>Postoperative IKS function score</td>
<td>79</td>
<td>82</td>
<td>0.07</td>
</tr>
<tr>
<td>Postoperative IKS knee score</td>
<td>90</td>
<td>90</td>
<td>0.94</td>
</tr>
<tr>
<td>Forgotten knee (%)</td>
<td>37</td>
<td>40</td>
<td>0.77</td>
</tr>
<tr>
<td>IKS function score gain</td>
<td>23</td>
<td>20</td>
<td>0.16</td>
</tr>
<tr>
<td>IKS knee score gain</td>
<td>32</td>
<td>29</td>
<td>0.16</td>
</tr>
</tbody>
</table>

Table 5  Changes in patellofemoral pain between the preoperative and postoperative assessments.

<table>
<thead>
<tr>
<th>Patellofemoral pain</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preoperative (data available for 683 knees)</td>
<td>78 (11.5%)</td>
<td>605 (88.5%)</td>
</tr>
<tr>
<td>Postoperative (data available for 460 knees)</td>
<td>39 (8.5%)</td>
<td>421 (91.5%)</td>
</tr>
</tbody>
</table>

Table 6  Postoperative clinical outcomes according to presence of lateral-compartment osteoarthritis (LCOA) in 909 cases of medial knee osteoarthritis managed with medial unicompartimental knee arthroplasty.

<table>
<thead>
<tr>
<th></th>
<th>LCOA</th>
<th>No LCOA</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>45</td>
<td>862</td>
<td></td>
</tr>
<tr>
<td>IKS knee score</td>
<td>85.6</td>
<td>90.7</td>
<td>0.01</td>
</tr>
<tr>
<td>IKS function score</td>
<td>80.7</td>
<td>82.4</td>
<td>0.5</td>
</tr>
<tr>
<td>KOOS pain</td>
<td>82.4</td>
<td>82.3</td>
<td>0.9</td>
</tr>
<tr>
<td>KOOS function</td>
<td>65.9</td>
<td>80.2</td>
<td>0.001</td>
</tr>
<tr>
<td>KOOS symptoms</td>
<td>81</td>
<td>86.8</td>
<td>0.02</td>
</tr>
<tr>
<td>Forgotten knee (%)</td>
<td>12.5</td>
<td>41</td>
<td>0.006</td>
</tr>
</tbody>
</table>

Figures

Figure 5  Survival curves according to body mass index (BMI).

Prosthesis survival rates after 10 years were similar in these two groups (82.5% and 83.6%, respectively) (Fig. 5).

Results according to anterior cruciate ligament status

The ACL was deemed deficient in 43 patients. This subgroup was too small to allow meaningful statistical comparisons.

Results according to the status of the patellofemoral joint

Patellofemoral pain was the only clinical criterion used to determine whether the patellofemoral compartment was involved (Table 5). The overall percentage of patients with patellar pain showed little change between the preoperative evaluation and last follow-up. Among knees without patellar pain preoperatively, 39 (6%) had patellar pain postoperatively; and among knees with patellar pain preoperatively, 78 (36%) had no patellar pain postoperatively.

Results according to the status of the other femoro-tibial compartment

This analysis was conducted only in the group of medial UKAs, as the number of lateral UKAs was too small. Of 862 knees with medial-compartment osteoarthritis, 50 (5.8%) also had involvement of the lateral compartment. The KOOS function score was 65.9 in these 50 patients compared to 80.2 in the patients without lateral-compartment involvement (P=0.001). The percentage of “forgotten knees” differed significantly between these two groups (P=0.006) (Table 6).

In the group of 82 lateral UKA procedures, patellofemoral pain was present preoperatively in five (6.25%) knees and postoperatively in three (3.75%) knees. However, there was no overlap between the knees with preoperative and postoperative patellofemoral pain.

Results according to implant design

The IKS score improvement was not significantly different between fixed and mobile implants (30.7 and 30.5 points, respectively). Similarly, active range of flexion was 118.3° and 114° in these two groups. Prosthesis survival after 10 years was 91.2% with fixed implants and 84.5% with mobile implants (non-significant difference). The IKS score improvement was also similar between the condylar-cut and condylar-resurfacing groups (29.4 and 32.4 points, respectively). In contrast, 10-year prosthesis...
survival was significantly better \((P=0.006)\) with cemented all-polyethylene tibial components than with cemented metal-backed tibial components \((89.7\% \text{ vs. } 76.4\%)\).

**Discussion**

The retrospective multicentre multi-surgeon design of our study mandates caution when interpreting the results. Sample sizes were too small for an analysis of ACL deficiency, lateral UKA, or cementless implant fixation. The 14.5% lost-to-follow-up rate, 15% rate of missing BMI data, and availability of KOOS questionnaire results in only 21% of cases constitute additional limitations of our study. However, the diversity of implant designs and, above all, the large sample size are major strengths.

Our results show, as expected, that the absolute IKS score values were related to age both before and after UKA but that the IKS score improvements increased with advancing age. The difference in prosthesis survival according to age is of concern. To simplify the results and increase the statistical power, we compared prosthesis survival in two age groups, < 70 years and \(\geq 70\) years. This analysis showed an 8-year decrease in survival. The impact of age on prosthesis survival has been underlined in previous studies \([2,4,31,32]\), in which the tibial implant and more specifically the polyethylene appeared to be the ‘weakest link’ \([2]\). Knee biomechanics after UKA are nearly normal \([33,34]\) and it is therefore unsurprising that wear occurs at the friction interface according to time elapsed and level of joint use. However, other factors no doubt contribute to induce unfavourable outcomes, most notably implant position \([35–41]\). Preoperatively, the only significant gender-related difference in our study was a better IKS function score in men. Postoperative IKS scores were not significantly different between men and women, in keeping with earlier data \([42]\). However, the IKS scores showed larger postoperative improvements in women than in men, with the difference being significant for the function score and nearly significant for the knee score. The longer prosthesis survival in men has not been reported previously. However, the small size of the difference should be noted. BMI had no significant influence on clinical outcomes or prosthesis survival, in agreement with other studies \([42–44]\). Bonutti et al. \([49]\), however, reported high failure rates in patients with BMI values greater than 35 kg/m\(^2\). As an intact ACL is among the patient selection criteria for UKA \([3–5,46]\), the number of knees with ACL deficiency was too small for an evaluation of the potential impact on UKA results. In patients with ACL deficiency, several groups have suggested combined ligament reconstruction and UKA \([47–49]\).

Another patient selection criterion when considering UKA is integrity of the other femoro-tibial compartment and of the patellofemoral compartment. This criterion was respected strictly in our sample. Other studies showed a major impact on clinical outcomes, with consistent postoperative persistence of pain related to degenerative changes in the other compartment \([50,51]\). In contrast, compartments that were intact preoperatively remained so after UKA, provided proper alignment was achieved \([52]\). In keeping with earlier studies, we found no evidence that a specific biomechanical characteristic of the implants, most notably fixed versus mobile design, was associated with better clinical outcomes \([53–58]\). In contrast, mechanical failure was significantly more common with cemented metal-backed implants. However, this implant design was used chiefly in patients who were relatively young and therefore more active. The small number of lateral UKA procedures in our study precluded the demonstration of significant differences with medial UKA. Outcomes of lateral UKA were similar to those of medial UKA in other studies \([59–61]\). Careful patient selection combined with rigorous implant positioning (whose accuracy increases with surgeon experience) are the factors most likely to convince sceptics of the usefulness of UKA in patients with osteoarthritis or condylar necrosis \([5,8,62–64]\).

**Conclusion**

Our study establishes the validity of UKA as a treatment option for unicompartmental knee osteoarthritis with an intact ACL. In young patients, the higher demands result in a greater risk of wear and therefore in poorer medium-term prosthesis survival. Another issue in young patients is the ability to achieve range-of-motion and stability results consistent with a ‘forgotten’ knee. In the future, improvements in polyethylene quality, together with greater implant position accuracy achieved using navigation or personalised cutting guides, may result in better outcomes in young patients.

**Disclosure of interest**

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

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- Clinique de la Clarence, rue Charles-Legay, 62460 Divion, France;
- Département de chirurgie orthopédique du CHU de Fort-de-France, BP 632, 97261 Fort-de-France, France;
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Factors

References


