Simultaneous bilateral unicompartmental knee arthroplasty surgery has benefits in low complication rate and cost-effectiveness: a systematic review

Nicolas Pujol 1, Yoshiki Okazaki,1,2 Takayuki Furumatsu2

ABSTRACT

Importance Bilateral knee osteoarthritis is frequent and the best choice of treatment remains questionable, especially when the surgeon has to consider simultaneous or staged bilateral unicompartmental knee arthroplasty (UKA).

Objective The purpose of this systematic review was to conduct a systematic review assessing the clinical outcomes associated with simultaneous bilateral and staged bilateral UKA.

Evidence review A literature search was conducted in June 2019 in Medline, PubMed and Embase. A full-text review of eligible studies was conducted by two investigators.

Findings A total of 10 retrospective studies were identified. These studies described the results of simultaneous bilateral UKA compared either to staged bilateral UKA or unilateral UKA. Results showed that the prevalence of mortality at a minimum of 30 days postoperatively, deep vein thrombosis, the rate of blood transfusion and reintervention were not higher in patients undergoing a one-stage bilateral UKA. The cost-effectiveness is in favour of doing a one-stage procedure due to the shortness of total hospital stay.

Conclusions and relevance One-stage simultaneous bilateral UKA can be performed without the postoperative complication, and result in cost savings for patients with symptomatic medial bilateral unicompartmental knee osteoarthritis. Further comparative studies are necessary to determine the best patient profile for such a surgery, and the technical considerations during surgery (consecutive surgery or simultaneous surgery with two operative teams).

Level of evidence IV.

INTRODUCTION

The prevalence of bilateral knee osteoarthritis (OA) has been shown to be as high as 5%. More interestingly, 20% of patients requiring a primary knee arthroplasty are affected by a bilateral unicompartmental OA and are destined to undergo a second contralateral surgery within a few years after the initial operation.

There are two options for these patients with two joints needing surgery: two procedures and two different hospital stays (common option), or one surgery (and one hospital stay) to treat simultaneously both joints.

There are some controversial data in the literature reporting the rates of perioperative complications after simultaneous total knee arthroplasty (TKA).

What is already known

- The treatment of bilateral knee osteoarthritis (OA) is well described when the best option is total knee arthroplasty.
- When the surgical option is bilateral unicompartmental knee arthroplasty (UKA), the knowledge is scarce.

What are the new findings

- There is no major additional complication of doing a one-stage bilateral UKA when compared with a two-stage UKA or unilateral UKA.
- One-stage bilateral UKA should be considered as the first-line treatment option for symptomatic end-stage bilateral unicompartmental OA, relative to the two-stage UKA for both knees.
- Cost-effectiveness is in favour of one single hospital stay for one-stage bilateral UKA.

Several meta-analysis and literature reviews have concluded that simultaneous bilateral TKA has a higher mortality and higher complication rate compared with staged bilateral TKA, while probably decreasing the incidence of deep infection or revision rate.

Unicompartmental knee arthroplasty (UKA) is a successful procedure for relieving pain and restoring function in cases with severe OA. The improving knowledge of the good indications, contraindications, technique and long-term outcomes leads to increasing use of UKA. There is a lack of data about the risks or usefulness of performing simultaneous versus staged UKA for treating painful bilateral unicompartmental knee OA.

The purpose of the study was to present comprehensive summary of the published data on bilateral UKA, comparing the outcomes that have shown to be important to patients and clinicians to allow decision-making in case of bilateral unicompartmental knee OA. It was hypothesised that a one-stage bilateral UKA is safe and effective.

METHODS

Identification and selection of studies

A systematic review was conducted according to the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). DOI: 10.1136/jisakos-2019-000382. Copyright © 2020 ISAKOS

The purpose of this systematic review was to conduct a systematic review assessing the clinical outcomes associated with simultaneous bilateral and staged bilateral UKA.

Evidence review A literature search was conducted in June 2019 in Medline, PubMed and Embase. A full-text review of eligible studies was conducted by two investigators.

Findings A total of 10 retrospective studies were identified. These studies described the results of simultaneous bilateral UKA compared either to staged bilateral UKA or unilateral UKA. Results showed that the prevalence of mortality at a minimum of 30 days postoperatively, deep vein thrombosis, the rate of blood transfusion and reintervention were not higher in patients undergoing a one-stage bilateral UKA. The cost-effectiveness is in favour of doing a one-stage procedure due to the shortness of total hospital stay.

Conclusions and relevance One-stage simultaneous bilateral UKA can be performed without the postoperative complication, and result in cost savings for patients with symptomatic medial bilateral unicompartmental knee osteoarthritis. Further comparative studies are necessary to determine the best patient profile for such a surgery, and the technical considerations during surgery (consecutive surgery or simultaneous surgery with two operative teams).

Level of evidence IV.
A comprehensive search was performed by two investigators (NP and YO) on Medline (PubMed) and Embase databases (articles published between January 1990 and June 2019). The following Medical Subject Headings and terms were searched in title and abstract: ‘uncompartmental knee replacement’, ‘unicompartmental knee arthroplasty’, ‘UKA’ and ‘bilateral’. All clinical studies were included (randomised and non-randomised clinical trials, multicentre studies, case reports, reviews, systematic reviews and meta-analyses). Additional articles were detected by searching through the reference lists of eligible studies. Studies meeting the following inclusion criteria were included: (1) patients undergoing bilateral UKA (one stage or two stages) for medial OA with intact cruciate ligaments; (2) complication data reported for both the one and two-stages for medial OA with intact cruciate ligaments; (2) complication data reported for both the one and two-stage surgery cohorts; and (3) total sample size of >30 patients. There were no limitations on the chosen cultural/language criteria. To reduce any possible selection bias, the two investigators independently assessed each of the studies for eligibility in the inclusion criteria. After judging of the title or the abstract by either reviewer, the full article was determined. Any disagreements about the contents were resolved through careful discussion until consensus was reached.

**Data extraction**

Data were extracted by two authors (NP and YO) subsequently after confirming the eligibility of studies. All pertinent data were extracted from article abstracts, texts, tables and figures. Participant basic data included: (1) general study information (study design, author, year of publication, level of evidence); (2) study subject data (sample size, gender, mean age, body mass index); (3) American Society of Anesthesiologists (ASA) physical status; and (4) follow-up data. The incidence of complications (pulmonary embolism (PE), deep vein thrombosis (DVT), cardiac complications, neurological complications, deep infection, superficial infection), reintervention or return to operative room as well as blood loss and transfusion, and length of hospital stay were also recorded.

**Quality assessment**

The quality of extracted studies was assessed by two reviewers (YO and TF) using the Methodological Index for Non-Randomized Studies (MINOS) assessment tool. There is a total of 12 items, with each criterion given a score of 0, 1 or 2, with maximum scores of 16 for non-comparative and 24 for comparative studies. A score of 0–8 or 0–12 was considered poor quality for non-comparative and comparative studies, respectively, while a score of 9–12 or 13–18 was fair quality, and a score of 13–16 or 19–24 was considered excellent quality. To evaluate the MINOS quality, inter-reviewer reliability was calculated using the intraclass correlation coefficient (ICC), with the 95% CI. Any controversy was crosschecked and resolved by a senior author (NP) to reach a final consensus.

**Statistical analysis**

For descriptive analysis, data are presented as total number, mean and SD. The analysis of postoperative outcomes was performed using RevMan (Review Manager V.5.3, The Cochrane Collaboration, Oxford, England). Dichotomous outcomes were described as OR with a fixed effects model, while continuous outcomes were reported as weighted mean difference (MD). The SD values were imputed from the median and range using a well-established statistical technique. Heterogeneity was quantified by the I² statistic (ie, <25% being low and 75% being high). All tests of significance were set at p<0.05.

**RESULT**

**Eligibility**

A flow chart of the studies found for this review was shown in figure 1. The literature search generated 772 relevant abstracts. The number of studies excluded at each stage of study selection is depicted according to the PRISMA guideline. Following full-text screening, 10 cohort studies met the inclusion criteria and were included for final analysis. The baseline characteristics of the included articles are provided in table 1. Details on all of the clinical outcomes were shown in table 2.

**Study quality**

All studies in this systematic review were non-randomised in design. This study included nine comparative studies and one non-comparative study, with a total of four level IV studies and six level III studies (table 1). There was a substantial level of agreement among quality assessment scores using the MINOS criteria (ICC=0.98; 95% CI 0.97 to 0.99). The mean MINOS score was 15.1±2.5 which indicates fair quality of evidence. Overall, all studies had a clearly stated aim. Most studies had an adequate contemporary control group and sufficient follow-up period. However, one study met prospective collection of data due to the other studies being retrospective, and most studies lacked an unbiased assessment of study.

**Postoperative outcome**

**DVT and PE**

Six studies with a total of 1029 patients were involved when comparing the prevalence of DVT and PE. In comparative analysis between one-stage UKA and two-stage UKA, the total ORs of DVT and PE were 0.52 (95% CI 0.1 to 2.2, p=0.52, figure 2A) and 1.94 (95% CI 0.2 to 41.1, p=0.67), respectively. In an analysis of one-stage bilateral UKA compared with unilateral UKA, the ORs of DVT and PE were 1.35 (95% CI 0.2 to 8.3) and 2.00 (95% CI 0.1 to 33) with no significant differences.
Table 1  Demographic data of patients undergoing a bilateral UKA (one or two-stage procedure)

<table>
<thead>
<tr>
<th>Study (year)</th>
<th>Level of evidence</th>
<th>Number of patients 1 stage/2 stages</th>
<th>Gender M-F 1 stage/2 stages</th>
<th>Age 1 stage/2 stages</th>
<th>BMI 1 stage/2 stages</th>
<th>ASA 1-2-3-4 (%) 1 stage/2 stages</th>
<th>Mean follow-up (months)</th>
<th>Consensus MINOS score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comparative studies: one-stage bilateral versus two-stage bilateral uni</td>
<td>Chan et al (2009)</td>
<td>III</td>
<td>159/80</td>
<td>92-67/35-45*</td>
<td>66.65</td>
<td>–</td>
<td>20.8-67.9/11.3-0/22.5-60-17.5-0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Berend et al (2011)</td>
<td>III</td>
<td>35/141</td>
<td>–</td>
<td>58.2/62.7*</td>
<td>30.9/33.3*</td>
<td>–</td>
<td>19.4/13.9*</td>
</tr>
<tr>
<td></td>
<td>Siedlecki et al (2016)</td>
<td>III</td>
<td>44/26</td>
<td>22-20/19-7</td>
<td>69.2/70</td>
<td>26.8/26.3</td>
<td>Mean 1.9/1.8</td>
<td>17.6/36.8*</td>
</tr>
<tr>
<td>Cohort study: bilateral uni (one-stage procedure)</td>
<td>Akhtar et al (2014)</td>
<td>IV</td>
<td>38/0</td>
<td>16–22</td>
<td>64</td>
<td>29.8</td>
<td>21-63-16-0-0</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Only one-stage bilateral uni</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comparative studies: one-stage bilateral uni versus one-stage unilateral uni</td>
<td>Romagnoli et al (2015)</td>
<td>III</td>
<td>75-116/99-200</td>
<td>67.5/68.2</td>
<td>30.1/28.8*</td>
<td>4.2-93-2.8/0-81.8-89.5-2.4-0</td>
<td>6</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Clavé et al (2018)</td>
<td>III</td>
<td>35-15/66-34</td>
<td>64.4/68.1</td>
<td>28.8/29.7</td>
<td>52-36-10-2/47-22-26-5</td>
<td>44.4/61.2</td>
<td>16</td>
</tr>
</tbody>
</table>

*Significant difference between groups, p<0.05.

ASA, American Society of Anesthesiologists; BMI, body mass index; MINOS, Methodological Index for Non-Randomized Studies; UKA, unicompartmental knee arthroplasty.
## Table 2  Details on all the studies included in the review

<table>
<thead>
<tr>
<th>Study (year)</th>
<th>Mean operating time (min)</th>
<th>DVT (n)</th>
<th>Pulmonary embolism (n)</th>
<th>Early minor complications (excluding DVT, pulmonary embolism or reinterventions)</th>
<th>Haemoglobin difference pre-postop (g/dL)</th>
<th>Blood transfusion (n)</th>
<th>Revision (n)</th>
<th>Mean length of stay (days)</th>
<th>Hospital cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chan et al (2009)</td>
<td>113.7/129.4*</td>
<td>–</td>
<td>0/0</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>0/0</td>
<td>5/12</td>
<td>–</td>
</tr>
<tr>
<td>Berend et al (2011)</td>
<td>–</td>
<td>0</td>
<td>2/0</td>
<td>0/0</td>
<td>–</td>
<td>0/0</td>
<td>0/2</td>
<td>1.7/2.5*</td>
<td>–</td>
</tr>
<tr>
<td>Chen et al (2013)</td>
<td>130/152.5</td>
<td>1/2</td>
<td>2/3</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>0/0</td>
<td>18 071/26 963*</td>
<td>–</td>
</tr>
<tr>
<td>Ma et al (2015)</td>
<td>94/96</td>
<td>1/2</td>
<td>24</td>
<td>–</td>
<td>–</td>
<td>0/0</td>
<td>1/2</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Biazzo et al (2019)</td>
<td>73.2/50.7*</td>
<td>0/0</td>
<td>0/0</td>
<td>–</td>
<td>–</td>
<td>0/0</td>
<td>0/1</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Siedlecki et al (2018)</td>
<td>75/95*</td>
<td>1/0</td>
<td>0/0</td>
<td>2/1</td>
<td>–</td>
<td>2/1</td>
<td>6.7/13.9</td>
<td>5626/11 766*</td>
<td>–</td>
</tr>
<tr>
<td>Cohort study; unilateral uni (one-stage procedure)</td>
<td>Akhtar et al (2014)</td>
<td>83/-</td>
<td>0</td>
<td>–</td>
<td>–</td>
<td>0</td>
<td>1</td>
<td>3.5</td>
<td>–</td>
</tr>
<tr>
<td>Yildiz et al (2019)</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>3/8</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

*Significant difference between groups, p<0.05.

DVT, deep vein thrombosis.

### Length of stay and hospital cost

The majority of studies included in this review reported length of stay and hospital costs. In 13 studies, the mean length of stay varied from 1.7 to 6.9 days for a one-stage unilateral UKA, with the mean length of stay for one-stage bilateral UKA being significantly higher (2.4 days, 95% CI 1.9 to 3.2) compared to unilateral UKA (1.74 days, 95% CI 2.0 to 2.5; figure 2A). The cumulative cost was significantly higher for bilateral UKA, with the total cost for bilateral UKA being 1.46 times (95% CI 0.9 to 2.2) compared to unilateral UKA. The total OR was 1.22 (95% CI 0.8 to 1.7; figure 2A). In 12 studies of one-stage bilateral UKA versus unilateral UKA, the OR of blood transfusion was 0.98 (95% CI 0.6 to 1.6) with no significant difference (p=0.78).

### Haemoglobin difference and blood transfusion

The prevalence of minor complications was decreased in the one-stage group when compared with the two-stage group (OR 0.40, 95% CI 0.1 to 1.3; figure 2A). In the two-stage group, the MD of haemoglobin loss was 1.04 g/dL (95% CI 0.1 to 1.19), while the two-stage group had a significant increase in the prevalence of minor complications. In the two-stage group, the total OR of blood transfusion was 2.40 (95% CI 1.3 to 4.4; p<0.01).

### Discussion

The most important finding of this study was that there is no difference in the prevalence of major additional complications between one-stage and two-stage bilateral UKA. Patients with simultaneous bilateral UKA showed the benefits including a shorter length of stay as well as cost-effectiveness in comparison with unilateral UKA. The majority of publications about bilateral knee arthroplasties related to TKAs reported that the benefits of bilateral UKA were similar to the unilateral procedure. However, in some studies, the mortality rate was higher in bilateral group (95% CI 1.3 to 4.4, p<0.01).

In three studies of one-stage unilateral versus two-stage unilateral TKA, the MD of haemoglobin loss was 1.04 g/dL (95% CI 0.1 to 1.19), while the two-stage group had a significant increase in the prevalence of minor complications. In the two-stage group, the total OR of blood transfusion was 2.40 (95% CI 1.3 to 4.4; p<0.01).

### All early minor complications were grouped (minor cardiac complications, neurological complications, superficial wound complications, infection). Six studies with a total of 1029 patients were involved in the analysis. The prevalence of these grouped complications was significantly higher in the one-stage group (OR 0.40, 95% CI 0.1 to 1.3; figure 2A). In two studies of one-stage bilateral UKA versus unilateral UKA, the MD of haemoglobin loss was 1.04 g/dL (95% CI 0.1 to 1.19), while the two-stage group had a significant increase in the prevalence of minor complications.
Systematic review

Figure 2  Comparative analysis in one-stage versus two-stage bilateral unicompartmental knee arthroplasty (UKA) including the (A) deep vein thrombosis (DVT), (B) minor complication, (C) blood transfusion, (D) reintervention and (E) length of hospital stay.

intraoperatively and postoperatively when compared with two-stage TKA (OR=11.52).\(^5\) In addition, the cost-effectiveness of bilateral one-stage TKA is not established ($24 596±$5652 for one-stage bilateral TKA vs $24 915±$5756 for two-stage bilateral TKA, p=0.586).\(^26\)

The difference between bilateral UKA and bilateral TKA is considered to be the invasiveness of the surgery. The results of this systematic review suggest that one-stage bilateral UKA is a safer procedure than two-stage bilateral UKA. Although the non-significance trend in the prevalence of PE was observed in staged bilateral UKA, there was a lower rate of DVT in one-stage bilateral UKA. Proximal DVT and PE were the major complications encountered, while Chan et al reported that patients with these complications did not receive chemical thromboprophylaxis and were treated only with intraoperative mechanical calf pumps and early mobilisation.\(^14\) Notably, no difference was observed in the prevalence of minor early complication and blood transfusion between the two groups. The loss of haemoglobin in the one-stage surgery could not be associated with the blood transfusion. These results can be associated with the fact that one-stage bilateral UKA offers the benefits of a single anaesthetic, reduced total operating time, shorter total hospital stay and shorter total recovery time. In the
two studies reporting cost analysis for bilateral UKA, there was also a significant difference in favour of the one-stage group. Moreover, our study revealed the lower OR of revision rate in one-stage bilateral UKA than in the staged surgery. Romagnoli et al described that an experienced surgeon (more than 2000 UKAs performed) was often responsible for one-stage bilateral operations as it leads to lower rates of revisions. Nevertheless, the one-stage surgery might be performed by many operators as standardised procedure, with supporting a trained resident on one side of leg by an experienced surgeon on the other side.

There are several limitations to the present study. First, the number of studies was low and non-randomised. Second, all included studies had a poor methodological quality and were level III or IV. The criteria of doing a single-stage procedure or a two-stage procedure are not well documented and may vary among studies. Patients with much comorbidity may have in first option a two-stage procedure. However, the distribution of ASA scores among patients was not different in any study. Third, whenever data from different studies and sources are combined, management of bilateral UKA may vary between authors. The uses of a tourniquet, of perioperative tranexamic acid, in the thromboprophylaxis protocol were not precisely reported. These factors may influence the incidence of blood loss, transfusion, DVT and PE. In addition, information about the blood transfusion has a disparity in the postoperative protocol because patients were treated according to their symptoms, not only haemoglobin levels, and the management of arthroplasties was changed since 2013. Finally, because of the inability in extracting the related information whether the operation in the one-stage group was done by a single surgeon consecutively or by two surgeons operating simultaneously, no definite recommendations can be made.

CONCLUSIONS

In patients with a severe symptomatic bilateral unicompartmental OA, a one-stage bilateral UKA can be considered as a safety operation and may be a better treatment option when compared with a two-stage procedure. Complications rates are not higher, often lower. Cost-effectiveness is in favour of a single hospital stay. This is completely different when considering bilateral TKA.

Contributors  NP designed the study, screened the related articles and wrote the paper. YO corrected the paper and screened the articles. TF corrected the paper.

Funding  The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests  None declared.

Patient consent for publication  Not required.

Provenance and peer review  Not commissioned; externally peer reviewed.

Data availability statement  Data are available in a public, open access repository. All data are available upon request.

ORCID iD  Nicolas Pujol http://orcid.org/0000-0002-2013-8926

REFERENCES


