Systematic Review

Disease progression, aseptic loosening and bearing dislocations are the main revision indications after lateral unicompartmental knee arthroplasty: a systematic review

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Keywords: Unicompartmental knee arthroplasty, Revision, Osteoarthritis

Abstract

Importance: Lateral unicompartmental knee arthroplasty (UKA) is a surgical option for patients with isolated lateral osteoarthritis but, in the procedure, has higher revision rates than medial UKA. The reason for this remains unclear; therefore, a better understanding of the indications for lateral UKA revision is needed.

Aim: The primary aim of this systematic review was to identify revision indications for lateral UKA. Secondary aims were to further investigate if revision indications were influenced by implant design and time from surgery.

Evidence review: A systematic literature review was performed according to the PRISMA 2020 guidelines. Search was performed in January 2022 in MedLine, EMBASE, CINAHL and the Cochrane Library using the keywords “knee arthroplasty”, “unicompartmental”, “reoperation”, synonyms and abbreviations. Articles published in 2000–2021 that were at least level III retrospective cohort studies with at least 10 lateral UKAs and reported all failure modes were included. Risk of bias was assessed using the ROBINS-I tool. Revision indications, patient characteristics, study design, implant types and time to failure were extracted from the selected studies. Collated data were tabulated and differences were tested using Chi-square or Fisher’s exact test.

Findings: A total of 29 cohort and 4 registry studies that included 7,668 UKAs met the inclusion criteria. Studies were judged as having moderate or severe risk of bias; this was associated with the retrospective nature of studies required to investigate long-term outcomes of knee arthroplasty. The main indications for lateral UKA revision were OA progression (35%), aseptic loosening (17%) and bearing dislocation (14%). The incidence of revision was similar for mobile-bearing implants (7.6%) and fixed-bearing (6.4%). For mobile-bearing implants, there was introduction of bearing dislocations as an additional mode of failure (24% cf. 0%, p < 0.001). For fixed-bearing implants, the incidence of revision was higher for all-polyethylene (13.9%) than metal-backed (1.8%) tibial components. Early lateral UKA failures were associated with bearing dislocations (sequential decrease from 69% under 6 months to 0% 10+ years, p < 0.001), whereas late failures were associated with OA progression (sequential increase from 0% under 6 months to 100% 10+ years, p < 0.01). Compared with medial UKA, OA progression (41% cf. 30%, p = 0.004), malalignment (2.7% cf. 0.8%, p < 0.001), instability (4% cf. 1%, p = 0.02) and bearing dislocations (20% cf. 10%, p < 0.001) were more common for lateral UKA.

Conclusions and relevance: OA progression, aseptic loosening and bearing dislocation were the three main revision indications for lateral UKA. Compared to medial UKA, OA progression, malalignment, instability and bearing dislocations were more common revision indications for lateral UKA. Higher survivorship of metal-backed fixed-bearing implants was found. The findings suggest that the outcomes of lateral UKA may be improved with more optimal alignment, gap balancing and patient selection.

Level of evidence: Level III systematic review.

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Introduction

Knee arthroplasty is an effective treatment for patients with end-stage osteoarthritis (OA) [1,2]. An estimated 50% of patients undergoing knee arthroplasty have disease isolated to one compartment and may be eligible for unicompartmental knee arthroplasty (UKA) instead of a total knee arthroplasty [3,4]. UKA of the medial compartment is most eligible for unicompartmental knee arthroplasty (UKA) instead of a total knee arthroplasty [3,4]. OA progression, malalignment, instability and bearing dislocations were more common for lateral UKA, which suggest that achieving optimal alignment and gap balancing may be of more importance with lateral UKA.

What is already known

- Lateral unicompartmental knee arthroplasty (UKA) has lower survivorship than medial UKA and potentially different mechanisms of failure due to anatomical differences between the compartments.
- The last review on this topic in 2016 reported that osteoarthritis (OA) progression (29%), aseptic loosening (23%) and bearing dislocation (10%) were the main revision indications; however, an update is due with the introduction of implant design changes and an increased number of publications on lateral UKA within the last five years.

What are the new findings

- The main indications for lateral UKA revision remain OA progression (35%), aseptic loosening (17%) and bearing dislocation (13%).
- Mobile-bearing lateral implants had a similar rate of failure (7.6%) compared to fixed-bearing implants (6.4%). For fixed-bearing implants, all-polyethylene components had a higher rate of failure (13.9%) compared with metal-backed (1.8%).
- Early revisions were associated with bearing dislocation, whereas late revisions were associated with OA progression.
- Compared with medial UKA, OA progression, malalignment, instability and bearing dislocations were more common for lateral UKA, which suggest that achieving optimal alignment and gap balancing may be of more importance with lateral UKA.

Methods

A systematic review of the literature was performed according to PRISMA 2020 protocol [21]. Each step was performed by one author (MLT), with any uncertainties discussed with the senior author (SWY). A consensus was reached before any data were included.

Search strategy

An electronic search was performed in January 2022, through the databases of MedLine, EMBASE, CINAHL and the Cochrane Library. The search strategy included the keywords “knee arthroplasty”, “knee prosthesis”, “unicompartmental”, “UKA”, “reoperation”, “failure”, “survival” and synonyms, as well as the MeSH terms ‘arthroplasty, replacement, knee’, “knee prosthesis”, “treatment failure”, “prosthesis failure” and “reoperation”. Detailed search strategies are appended (Appendix A).

After the removal of duplicates, articles were evaluated for relevance based on title and abstract. Conference proceedings, newsletters and reviews were excluded. Registry reports were also checked and included if failure modes were reported separately for medial and lateral UKA. The remaining articles were then assessed using the pre-defined inclusion and exclusion criteria presented below.

Inclusion/exclusion criteria

The inclusion criteria were (1) English language articles in humans published between January 2000 and December 2021 (inclusive); (2) minimum level III retrospective cohort studies using the Oxford Centre for Evidence-Based Medicine 2011 Levels of Evidence (OCEBM [22]); (3) primary lateral UKA; (4) included more than ten lateral UKA; (5) reported all failure modes; (6) a majority of the patients had a primary diagnosis of OA. The exclusion criteria were (1) case reports; (2) studies on patients with previous surgery in the same knee, such as high tibial osteotomy or medial UKA; (3) failures not reported separately as medial or lateral; (4) multiple reports on the same study or with overlapping patient cohorts. For the latter, only the most recently published study was included.

Failure was defined as having a revision event, classified as the addition, exchange or removal of one or more prosthetic components or a periprosthetic joint infection. The studies were grouped according to the outcomes of interest, which were the overall indications for lateral UKA revision, mobile-bearing vs. fixed-bearing components, all-PE vs. metal-backed fixed-bearing components and time from primary surgery.

Study quality assessment

Studies were assessed for the risk of bias using the ROBINS-I (“Risk of Bias in Non-randomised Studies - of Interventions”) tool [23]. Studies were evaluated for the risk of confounding, participant selection, classification of interventions, deviations from intended interventions, missing data, outcome measurements and selective reporting. The items were
scored as “low risk of bias”, “moderate risk of bias”, “serious risk of bias”, “critical risk of bias” or “insufficient information”. The overall risk of bias judgement for each study was based on the worst judgement assigned within any one domain for that study.

Data extraction

The data were extracted from the selected studies into tables using Microsoft Excel. The following data were extracted from the studies: author, year, number of UKAs, number of patients, follow-up times (means/medians and range), number of revisions, implant types including bearing type and fixation, time to revision for each case (if available) and counts of each revision indication. The categories of revision indications used were aseptic loosening, OA progression, pain, instability, periprosthetic joint infection, wear, bearing dislocation, malalignment, fracture, tibial subsidence, other and unknown [24]. Additionally, we also extracted means and ranges of patient age, body mass index and gender splits if they were reported.

All studies reported the implants that were used; however, some studies did not report bearing (mobile-bearing vs. fixed-bearing) or tibial component (all-PE vs. metal-backed) type. Bearing type could be inferred from the implants used, however, the tibial component could not; therefore, studies that did not report the latter were excluded from that subgroup analysis. Similarly, some studies did not report time to failure for each event and these were excluded from the “time from primary surgery” subgroup analysis. Studies that did not report patient characteristics or mean time of follow-up were included in the analyses as these were not the main outcomes of this review. As studies were only included in each of the three subgroup analyses if they reported the outcome of interest, no additional data preparation were needed for the following analyses. To avoid the impacts of clustering as a result of repeated reporting of outcomes on the same group of patients, one of the exclusion criteria used was the removal of duplicate reports from the same patient cohort. As the subgroup analyses did not include repeated measurements or missing data, we did not perform additional sensitivity analyses for the data.

Ethical approval was not sought for this review as the study used previously published and publicly available data with no identifiable information.

Statistical analysis

Categorical variables were tabulated as absolute frequencies and percentages. Statistical analyses were performed with IBM SPSS Statistics version 28 (IBM corp., Armonk, NY, USA). Chi-squared tests with Haldane-Anscombe correction or Fisher’s exact test and relative risk were used for between-group comparisons. In all cases, the null hypothesis was that groups had equal proportions of revision indications. The tests were two sided and p-values below 0.05 were considered significant.

Results

Study selection and quality

An initial 3,816 records were retrieved from a literature search performed according to PRISMA 2020 guidelines (Fig. 1). Following the removal of duplicates and screening, a total of 117 full-text records were obtained and assessed for eligibility. A total of 29 cohort [8,14,18, 25–50], 3 registry studies [51–53] and one registry [54], which included 7,668 UKAs, were selected for analysis (Table 1). Whilst a further seven studies met the inclusion and exclusion criteria, these were found to be overlapping reports of the same study cohort and were excluded. Strength of the evidence was moderate as the 27 retrospective and 6 prospective observational cohorts were judged to present either moderate or serious risk of bias (Table 2). Further information on patient characteristics and specific implants used in these studies are available in Appendix B.

Revision indications for lateral UKA

Some differences were found between the revision indications reported by cohort and registry studies, therefore these were reported separately (Table 1). From the cohort studies, 222 revisions (7.9% or 1.35 per 100 observed component years (ocy)) were reported from a total of 2,802 lateral UKAs, with a mean follow-up of 5.1 years. The most common revision indication was OA progression to the other compartment (41%), followed by bearing dislocation (20%) and aseptic loosening (10%). From the registry studies, 371 revisions (7.6%, 1.96 per 100ocy) were reported from a total of 4,866 lateral UKAs, with a mean follow-up of 5 years. Similar to cohort studies, the most common revision indication reported by registry studies was OA progression (30%). However, in contrast with the cohort studies, the second most common indication was aseptic loosening (20%), followed by bearing dislocation (8%). Compared with registry studies, cohort studies reported larger proportions of OA progression (41% cf. 30%, p = 0.004) and bearing dislocation (20% cf. 8%, p < 0.001), but lower proportions of aseptic loosening (10% cf. 20%, p = 0.001), pain (6% cf. 11%, p = 0.03) and “other” reasons (5% cf. 11%, p = 0.02).

Fixed-vs. mobile-bearing components

Data from 32 studies were available to compare mobile-bearing vs. fixed-bearing implants; 10 studies (n = 2,268) with mobile-bearing implants [14,18,28,32,33,37,38,41,50,53], 18 studies (n = 1,469) with fixed-bearing [8,26,42–49,27,30,31,34–36,39,40] and 4 additional studies that reported outcomes for both (n = 1,743 mobile-bearing, n = 790 fixed-bearing) [25,29,46,51]. 18 studies had a moderate risk of bias [8,18,44–50,53,26,31,33,34,37,39,42,43], and 14 studies had a serious risk of bias [14,25,40,41,51,52,30,32,35,36,38]. Mobile-bearing lateral implants had a similar incidence of revision as fixed-bearing: 305 revisions were reported out of 4,011 mobile-bearing UKAs (7.6% revised, 1.88 per 100 ocy, mean follow-up 4.2 years) compared with 144 revisions out of 2,259 fixed-bearing UKAs (6.4% revised, 1.09 per 100 ocy, mean follow-up 5.4 years; Table 3). Compared with the fixed-bearing cohort, revisions for the mobile-bearing cohort were less likely to be associated with OA progression (21% cf. 47%, p < 0.001). The use of mobile-bearing implants introduced a risk of bearing dislocation not found with fixed-bearing implants (24% cf. 0%, p < 0.001).

All-PE vs. metal-backed components (fixed-bearing)

Data from 15 studies reported the use of all-PE vs. metal-backed fixed-bearing implants; 5 studies (n = 267) with all-PE implants [25,34,36,40, 53]; 10 studies (n = 660) with metal-baked implants [8,26,27,29,39, 42–46]. Nine studies had a moderate risk of bias [8,26,34,39,42–46] and six studies had a serious risk of bias [25,27,29,30,36,40]. For fixed-bearing implants, the incidence of revision was higher with the use of all-PE tibial components than metal-backed: 37 revisions were reported out of 267 all-PE implants (13.9% revised, 3.62 per 100 ocy, mean follow-up 4.8 years) compared with 12 revisions out of 660 metal-backed implants (1.8% revised, 0.42 per 100 ocy, mean follow-up 4.5 years; Table 4).

Time to failure

A total of 14 studies reported individual time to failure for each revision event, and these were collated to report on outcomes by the time of surgery [8,14,44–46,50,18,26,27,29,33,36,37,41]. Nine studies had a moderate risk of bias [8,18,26,33,37,44–46,50] and five studies had a serious risk of bias [14,27,29,36,41]. From these studies, 76 revisions were reported out of 1,413 lateral UKAs (5.4% revised, 1.07 per 100 ocy, mean follow-up 4.6 years). The proportion of revisions due to OA progression was 0% in the first six months of surgery but increased...
sequentially over time to account for 100% of all revisions performed after 10 years \( (p < 0.001, \text{Fig. 2}) \). In contrast, the proportion of revisions due to bearing dislocations decreased sequentially over time, from 69% of all revisions in the first six months of surgery to 0% after 10 years \( (p < 0.001) \). There were no identifiable trends over time for the other revision indications.

**Discussion**

This systematic review has presented an updated and more detailed synthesis of revision indications following lateral UKA. The main indications were OA progression (41% of all failures), aseptic loosening (20%) and bearing dislocation (10%). When bearing type was compared, revision for mobile-bearing UKA was more likely to be associated with OA progression and bearing dislocations. When comparing time to revision, bearing dislocations were the most common reason for early revision, whereas OA progression was most common in late revisions.

There were some differences between what was reported in cohort vs. registry studies. Cohort studies reported larger proportions of OA progression and bearing dislocations, but lower proportions of aseptic loosening, “pain” and “other” reasons compared with registry studies. This may be explained by the difference in the level of detail that can be captured by cohort studies and registries: registries tend to report a higher level of “unexplained pain” and “unknowns” and may have lower capture of certain revision types, such as bearing dislocations \([55, 56]\).

The subgroup analyses revealed that both implant survival and revision indications varied according to implant design. The incidence of revision was higher with the use of mobile-bearing and all-PE components than fixed-bearing and metal-backed, respectively. This was associated with an additional risk of bearing dislocations that were not found with fixed-bearing implants. These mobile-bearing implants were also associated with lower proportions of OA progression. This can be explained by implant design; the mobile-bearing design allows for more balanced surface and subsurface contact stresses \([57]\). There has been relatively a high usage of mobile-bearing implants for lateral UKA \([54]\) (Table 3). The mobile-bearing implants included in this study were AMC-UKA (Corin, Cirencester, UK), Oxford Domed (Zimmer Biomet, Warsaw, IN) and Preservation (De Puy, Johnson&Johnson, Raynham, MA), with the Oxford Domed being the most common (92%, from studies that reported numbers of each implant type). Given the increased laxity of the lateral compartment and resulting risk of bearing dislocations \([18]\), mobile-bearing implants for lateral UKA may become less common.

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**Fig. 1.** PRISMA 2020 flow diagram of the selection process for studies reporting revision indications for lateral unicompartmental knee arthroplasty.
### Table 1
Revision indications for lateral unicompartmental knee arthroplasty.

| Study                  | Recruitment n (cohort) | n (failure) | Asepsis loosen | OA | Pain | Instability | PJII | Wear | Bearing dislocation | Malalign | Fracture | Tibial subsid | Other | Unknown | Bearing | Tibial component | Cement |
|------------------------|------------------------|-------------|----------------|----|------|-------------|------|------|-------------------|----------|----------|--------------|-------|---------|---------|-------------------|--------|
| Cohort studies         |                        |             |                |    |      |             |      |      |                   |          |          |              |       |         |         |                   |        |
| Argenson et al. 2008   | 1982–2004              | 38          | 5              | 1  | 4    |             |      |      |                   |          |          |              | Fixed |         |         | M-B               | Cem    |
| Berend et al. 2012 [45]| 2004–2008              | 100         | 1              |    |      |             |      |      |                   |          |          |              | Fixed |         |         | M-B               | Cem    |
| Burger et al. 2020 [46]| 2007–2016              | 171         | 3              | 1  | 1    |             |      |      |                   |          |          |              | Fixed |         |         | M-B               | Cem    |
| Demange et al. 2015    | 2003–2009              | 53          | 5              | 2  | 2    |             |      |      |                   |          |          |              | Fixed |         |         | nr                | Cem    |
| Deroche et al. 2020 [48]| 1988–2014              | 268         | 38             | 4  | 26   | 1           | 3    |      |                   |          |          |              | Fixed | Mixed   |         | Mixed             | mixed  |
| Edmiston et al. 2018   | 2003–2014              | 65          | 4              | 2  | 1    |             |      |      |                   |          |          |              | Fixed |         |         | nr                | Cem    |
| Forster et al. 2007 [25]| 2001–2003              | 30          | 3              | 3  |      |             |      |      |                   |          |          |              | Mixed | Mixed   |         | M-B               | Cem    |
| Kennedy et al. 2020 [18]| 2004–2015              | 325         | 34             | 1  | 12   | 1           |      |      |                   |          |          |              | Fixed |         |         | M-B               | Cem    |
| Kim et al. 2016 [27]   | 2011–2014              | 29          | 1              |    |      |             |      |      |                   |          |          |              | Fixed |         |         | M-B               | Cem    |
| Lies & Herzberg 2013   | 2002–2009              | 117         | 12             | 6  | 3    |             |      |      |                   |          |          |              | Mobile |         |         | M-B               | Cem    |
| Marson et al. 2014 [29]| 2007–2011              | 27          | 1              |    |      |             |      |      |                   |          |          |              | Mixed |         |         | M-B               | Cem    |
| Murray et al. 2021 [30]| 1974–1994              | 81          | 19             | 3  | 10   |             |      |      |                   |          |          |              | Fixed | all-PE |         | Cem               |        |
| Newman et al. 2017     | 2005–2009              | 64          | 7              | 3  | 1    | 2           |      |      |                   |          |          |              | Mobile |         |         | nr                | Cem    |
| [41] Romagnoli et al. 2013 | 1991–2010            | 177         | 11             | 5  | 3    |             |      |      |                   |          |          |              | Fixed |         |         | nr                | Cem    |
| Saxler et al. 2004 [32]| 1991–2000              | 46          | 5              | 1  |      |             |      |      |                   |          |          |              | Mobile |         |         | M-B               | Mixed  |
| Schellau et al. 2013   | 2009–2011              | 25          | 2              | 1  |      |             |      |      |                   |          |          |              | Mobile |         |         | M-B               | Cem    |
| Schmidt et al. 2021 [34]| 1990–2017              | 36          | 7              | 1  | 5    |             |      |      |                   |          |          |              | Fixed | all-PE |         | Cem               |        |
| Schrakeppeper et al. 2020 | 2011–2016             | 11          | 0              |    |      |             |      |      |                   |          |          |              | Fixed |         |         | nr                | Cem    |
| Smith et al. 2014 [36]| 2002–2011              | 101         | 4              | 1  |      |             |      |      |                   |          |          |              | Fixed | all-PE |         | Cem               |        |
| Streit et al. 2012 [37]| 2006–2009              | 49          | 3              | 1  | 2    |             |      |      |                   |          |          |              | Mobile |         |         | M-B               | Cem    |
| Tu et al. 2010 [8]     | 2007–2010              | 121         | 1              |    |      |             |      |      |                   |          |          |              | Fixed |         |         | M-B               | Cem    |
| Walker et al. 2018 [38]| 2006–2014              | 344         | 35             | 1  | 6    | 3           | 3    |      |                   |          |          |              | Mobile |         |         | M-B               | Cem    |
| Walker et al. 2020 [39]| 2013–2017              | 52          | 0              |    |      |             |      |      |                   |          |          |              | Fixed |         |         | M-B               | Mixed  |
| Walton et al. 2006 [40]| 1984–1998              | 32          | 7              | 1  | 6    |             |      |      |                   |          |          |              | Fixed |         |         | all-PE            | Cem    |
| Weston-Simmons et al. 2014 [41]| 2004–2012       | 265         | 12             | 2  | 2    | 2           | 4    | 1    |                   |          |          |              | Mobile |         |         | M-B               | Cem    |
| Zambianchi et al. 2020 | 2013–2016              | 67          | 0              |    |      |             |      |      |                   |          |          |              | Fixed |         |         | M-B               | Cem    |

| Registry studies       |                        |             |                |    |      |             |      |      |                   |          |          |              |       |         |         |                   |        |
| AOANJR 2021 [54]       | 1999–2020              | 1,285       | 140            | 36 | 68   | 10          | 2    |      |                   |          |          |              | Mixed |         |         | Mixed             | mixed  |
| Baker et al. 2012 [51] | 2005–2010              | 2,052       | 71             | 17 | 3    | 15          | 11   | 7    |                   |          |          |              | Mixed |         |         | Mixed             | Mixed  |
| Burger et al. 2020 [52] | 2007–2017              | 537         | 63             | 10 | 31   | 4           | 8    | 2    |                   |          |          |              | Mixed |         |         | Mixed             | Mixed  |
| Mohammad et al. 2021   | 2005–2017              | 992         | 97             | 14 | 12   | 15          | 3    | 6    |                   |          |          |              | Mobile |         |         | M-B               | Cem    |

| Total n (cohort)       | 2,802                  | 222          | 22             | 91 | 13   | 8           | 14   | 0    | 45               | 6        | 7       | 11          | 4     |         |         |                   |        |
| Total % (cohort)       | 9.9                    | 41.0         | 5.9            | 3.6| 6.3  | 0.0         | 20.3 | 2.7  | 3.2              | 0.5      | 5.0    | 1.8         |       |         |         |                   |        |

| Total n (registry)     | 4,866                  | 371          | 77             | 114| 44   | 24          | 25   | 5    | 29               | 9        | 7      | 0           | 41    | 12      |         |                   |        |

(continued on next page)
Table 1 (continued)

| Study Recruitment | n (cohort) | OA | Pain | Instability | EHI | Wear | Bearing dislocation | Malalignment | Frezure | Tissue subsidence | Component fixation | Comment |
|-------------------|------------|----|------|-------------|-----|------|---------------------|-------------|---------|-----------------|-------------------|---------|
| OA ANJRR, Australian Orthopaedic Association National Joint Replacements Registry | 19.9 | 29.5 | 11.4 | 6.2 | 6.5 | 6.9 | 9.6 | 5.4 | 6.6 | 12.5 | 2.3 | 2.3 | 0.0 |
| AO M-B, metal-backed | 0.007 | 0.009* | <0.001* | NS | NS | NS | <0.001* | NS | NS | NS | <0.001* | NS | NS |
| Other unknown | 10.6 | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 |
| Other | 8.6 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 |
| Total % (registry) | 19.9 | 29.5 | 11.4 | 6.2 | 6.5 | 6.9 | 9.6 | 5.4 | 6.6 | 12.5 | 2.3 | 2.3 | 0.0 |
| Comparison of revision indications over time from surgery has not previously been reported. In this review, we found that revisions due to OA progression increased over time, with a highest incidence at 10+ years following surgery. In contrast, revisions due to bearing dislocations decreased over time, with the highest incidence within six months of surgery. Bearing dislocations are considered to be associated with suboptimal surgical technique [5,60], and the events are reported to take place within the first two years of surgery [50,63]. In comparison, OA progression may sometimes be reported as unexplained pain in the early-term because it may be undetectable in routine radiographs [24]. OA progression following UKA has also been associated with suboptimal patient selection [13,62]. Overall, the study findings suggest that there may be potential for improving the outcomes of lateral UKA with improved component positioning and more careful patient selection.

When the findings from this study were compared with our recent systematic review on revision indications for medial UKA [10], we found that lateral UKAs were more likely to be revised for OA progression (41% cf. 30%, p = 0.004), malalignment (2.7% cf. 0.8%, p = 0.02), bearing dislocations (20% cf. 10%, p < 0.001) and instability (4% cf. 1%, p = 0.02; Fig. 3). In contrast, medial UKAs were more likely to be revised for aseptic loosening (24% cf. 10%, p < 0.01). There are anatomical and kinematic differences between the medial and lateral compartments. The lateral plateau is convex and smaller than the concave medial plateau, and lateral ligaments are more lax in flexion [11]. To explain the higher incidence of OA progression with lateral UKA, van der List et al. proposed that this may be associated with the smaller lateral joint space and potential of higher loading on the medial condyle with a sub-optimally balanced UKA [13]. The aetiology of OA progression following UKA is not well-understood; however, it has also been linked to patient selection [13,62]. The relative laxity of the lateral compartment, particularly in deep flexion, may explain the increased risk of a bearing dislocation with lateral UKA. The “domed” Oxford Partial Knee was introduced to address this issue; however, a significant risk of bearing dislocations remained. The study findings suggest that surgeons may need to pay particular attention to appropriate patient selection and achieving optimal balancing during lateral UKA to avoid an increased risk of revision.

There are some limitations to this review. First, there is a paucity of studies reporting the outcomes of lateral UKA in the literature because the procedure is not commonly performed. This review therefore included studies with many different implant types and in some cases, small cohort sizes, which limited the subgroup analyses that could be conducted. However, the inclusion of a variety of implant types may also enhance generalisability of the study findings. Second, we could not compare outcomes based on implant fixation, as there was a lack of reports on cement-less fixation. This will likely be an area of interest for future research. There were also some limitations with the review process and the available body of evidence. For logistical reasons, study screening and data extraction were mostly performed by one author. However, any uncertainties were discussed with a senior author to reach a consensus, which allowed for confidence in the overall study findings. The strength of the evidence was moderate as the included studies were judged to have moderate to serious risk of bias, particularly with confounding, patient selection and reporting bias. This was because the studies included were observational and mostly retrospective due to the
studies. Other includes: implant failure, osteonecrosis, post-traumatic wound dehiscence, arthrofibrosis/stiffness, recurrent haemarthrosis, locking, superficial infection, impingement, ligament injury, component dissociation *significant p-value (<0.05).

Table 2
Summary of risk of bias assessment for the selected studies according to the ROBINS-I domains.

| Study                          | Confounding | Participant selection | Classification of interventions | Deviation from intended intervention | Missing data | Outcome measurements | Selective reporting | Overall |
|--------------------------------|-------------|-----------------------|---------------------------------|--------------------------------------|--------------|----------------------|---------------------|---------|
| Cohort studies                 |             |                       |                                 |                                      |              |                      |                     |         |
| Argenson et al. 2008 [44]      | Moderate    | Low                   | Low                             | Low                                  | Low          | Low                  | Moderate            | Moderate |
| Berend et al. 2012 [45]        | Moderate    | Low                   | Low                             | Low                                  | Low          | Low                  | Low                 | Moderate |
| Burger et al. 2020 [46]        | Moderate    | Low                   | Low                             | Low                                  | Low          | Low                  | Low                 | Moderate |
| Demange et al. 2015 [47]       | Moderate    | Low                   | Low                             | Low                                  | Low          | Low                  | Moderate            | Moderate |
| Deroche et al. 2020 [48]       | Moderate    | Low                   | Low                             | Low                                  | Low          | Low                  | Low                 | Moderate |
| Edmiston et al. 2018 [49]      | Moderate    | Low                   | Low                             | Low                                  | Low          | Low                  | Moderate            | Moderate |
| Forneil et al. 2018 [50]       | Moderate    | Low                   | Low                             | Low                                  | Low          | Low                  | Moderate            | Moderate |
| Foster et al. 2007 [51]        | Serious     | Low                   | Low                             | Low                                  | Low          | Moderate             | Moderate            | Serious |
| Gill & Nicolai 2019 [43]       | Moderate    | Low                   | Low                             | Low                                  | Low          | Moderate             | Moderate            | Moderate |
| Greco et al. 2019 [26]         | Moderate    | Low                   | Low                             | Low                                  | Low          | Low                  | Low                 | Moderate |
| Kennedy et al. 2020 [18]       | Moderate    | Low                   | Low                             | Low                                  | Low          | Low                  | Low                 | Moderate |
| Kim et al. 2016 [57]           | Serious     | Moderate              | Low                             | Low                                  | Low          | Low                  | Low                 | Serious |
| Liebs & Herzberg 2013 [28]     | Seriouse    | Low                   | Low                             | Low                                  | Low          | Moderate             | Moderate            | Serious |
| Mannon et al. 2014 [29]        | Serious     | Low                   | Low                             | Low                                  | Low          | Moderate             | Low                 | Serious |
| Murray et al. 2021 [30]        | Serious     | Moderate              | Low                             | Low                                  | Low          | Low                  | Low                 | Serious |
| Newman et al. 2017 [14]        | Serious     | Low                   | Low                             | Low                                  | Low          | Low                  | Low                 | Serious |
| Romagnoli et al. 2013 [31]     | Moderate    | Low                   | Low                             | Low                                  | Low          | Moderate             | Serious            | Moderate |
| Sanders et al. 2004 [41]       | Low         | Low                   | Low                             | Low                                  | Moderate     | Low                  | Moderate            | Moderate |
| Scheifiet al. 201 y [33]       | Moderate    | Low                   | Low                             | Low                                  | Low          | Moderate             | Moderate            | Moderate |
| Schmidt et al. 2021 [34]       | Moderate    | Low                   | Low                             | Low                                  | Moderate     | Moderate             | Moderate            | Moderate |
| Schraknepper et al. 2020 [35]  | Serious     | Low                   | Low                             | Low                                  | Low          | Moderate             | Moderate            | Moderate |
| Smith et al. 2014 [36]         | Moderate    | Low                   | Low                             | Low                                  | Low          | Moderate             | Moderate            | Moderate |
| Streit et al. 2012 [37]        | Moderate    | Low                   | Low                             | Low                                  | Low          | Low                  | Moderate            | Moderate |
| Tu et al. 2020 [38]            | Moderate    | Low                   | Low                             | Low                                  | Low          | Low                  | Moderate            | Moderate |
| Walker et al. 2018 [39]        | Moderate    | Low                   | Low                             | Low                                  | Low          | Low                  | Low                 | Moderate |
| Walker et al. 2020 [39]        | Moderate    | Low                   | Low                             | Low                                  | Low          | Low                  | Moderate            | Moderate |
| Walton et al. 2016 [40]        | Serious     | Low                   | Low                             | Low                                  | Low          | Moderate             | Low                 | Moderate |
| Weston-Simmons et al. 2014 [41]| Serious     | Low                   | Low                             | Low                                  | Low          | Moderate             | Moderate            | Moderate |
| Zambianchi et al. 2020 [42]    | Moderate    | Low                   | Low                             | Low                                  | Low          | Low                  | Low                 | Moderate |
| Registry studies               |             |                       |                                 |                                      |              |                      |                     |         |
| AOANJRR 2021 [54]              | Serious     | Low                   | Low                             | Low                                  | Low          | Low                  | Moderate            | Moderate |
| Baker et al. 2012 [51]         | Serious     | Moderate              | Low                             | Low                                  | Low          | Low                  | Low                 | Moderate |
| Burger et al. 2020 [52]        | Serious     | Moderate              | Low                             | Low                                  | Low          | Low                  | Low                 | Moderate |
| Mohammad et al. 2021 [53]      | Moderate    | Low                   | Low                             | Low                                  | Low          | Low                  | Low                 | Moderate |

AOANJRR, Australian Orthopaedic Association National Joint Replacements Registry.

Table 3
Revision indications for lateral unicompartmental knee arthroplasty by bearing type (fixed-bearing vs. mobile-bearing).

| Implant design | Fixed-bearing | Mobile-bearing | Fisher's exact test (p-value) | Relative risk |
|----------------|---------------|----------------|-------------------------------|---------------|
| Number of UKA revisions (%) | 144 (6.4) | 305 (7.6) | | |
| Failure per 100 ocy* | 1.09 | 1.88 | | |
| Aseptic loosening | 22 (14.4) | 43 (13.7) | 0.89 | 1.1 |
| OA progression | 72 (47.1) | 65 (20.6) | <0.001* | 2.3 |
| Pain | 13 (8.5) | 34 (10.8) | 0.51 | 0.8 |
| Instability | 7 (4.6) | 14 (4.4) | 1.0 | 1.0 |
| PJI | 12 (7.8) | 18 (5.7) | 0.42 | 1.4 |
| Wear | 0 (0) | 2 (0.6) | 0.68 | 0.7 |
| Bearing | 0 (0) | 77 (24.4) | <0.001* | 0.03 |
| Dislocation | 8 (5.2) | 6 (1.9) | 0.08 | 2.7 |
| Malalignment | 5 (3.3) | 6 (1.9) | 0.35 | 1.7 |
| Fracture | 1 (0.7) | 0 (0) | 0.25 | 4.1 |
| Tibial | 7 (4.6) | 40 (12.7) | 0.01* | 0.4 |
| Otherb | 5 (3.3) | 10 (3.2) | 1.0 | 1.0 |

OA, osteoarthritis; ocy, observed component years; PJI, periprosthetic joint infection; NS not significant; UKA, unicompartmental knee arthroplasty *Only 9 studies from the mobile-bearing cohort and 17 from the fixed-bearing cohort reported mean follow-up times, therefore these estimates are based on a subset of studies. Other includes: implant failure, osteonecrosis, post-traumatic wound dehiscence, arthrofibrosis/stiffness, recurrent haemarthrosis, locking, superficial infection, impingement, ligament injury, component dissociation *significant p-value (<0.05). long follow-up times required and low incidence of revision arthroplasty. However, with the reporting of relevant patient and implant characteristics (Appendix B), it is hoped that the findings are still widely transferable, for example, when considering potential bias due to differences in baseline patient demographics. Despite these limitations, this review

Table 4
Revision indications for fixed-bearing lateral unicompartmental knee arthroplasty by type of tibial component (all-PE vs. metal-backed).

| Implant design | All-PE | Metal-backed |
|----------------|--------|--------------|
| Number of UKA revisions (%) | 37 (13.9) | 12 (1.8) |
| Failure per 100 ocy* | 3.62* | 0.42 |
| Aseptic loosening | 5 (13.5) | 2 (16.7) |
| OA progression | 22 (59.5) | 6 (50.0) |
| Pain | 0 (0) | 3 (25.0) |
| Instability | 0 (0) | 0 (0) |
| PJI | 1 (2.7) | 1 (8.3) |
| Wear | 0 (0) | 0 (0) |
| Bearing dislocation | 0 (0) | 0 (0) |
| Malalignment | 1 (2.7) | 0 (0) |
| Fracture | 3 (8.1) | 0 (0) |
| Tibial subsidence | 1 (2.7) | 0 (0) |
| Otherb | 0 (0) | 0 (0) |
| Unknown | 4 (10.8) | 0 (0) |

OA, osteoarthritis; ocy, observed component years; PE, polyethylene; PJI, periprosthetic joint infection; NS not significant; UKA, unicompartmental knee arthroplasty *Only 8 mobile-bearing studies and 17 fixed-bearing studies reported follow-up times, therefore estimates are based on a subset of studies. Other includes: arthrofibrosis/stiffness, component dissociation (not further defined), impingement, implant failure, ligament injury, locking, osteonecrosis, post-traumatic wound dehiscence, recurrent haemarthrosis, superficial infection.
was able to present an updated synthesis on revision indications reported for lateral UKA and demonstrated that these indications were associated with implant design and time from surgery. The findings from this study can be used to inform surgeons of the specific revision risks associated with use of lateral UKA.

**Conclusion**

In conclusion, despite recent introduction of improved component designs, OA progression remained the main revision indication for lateral UKA, followed by aseptic loosening and bearing dislocation. Compared to medial UKA, OA progression, malalignment, instability and bearing dislocations were more common indications for lateral UKA revision. Metal-backed fixed-bearing implants had lower reported revision rates compared with implants with all-PE tibial components. The findings suggest that the outcomes of lateral UKA may be improved with more optimal alignment, gap balancing and patient selection.

**Registration**

This review was not registered.

**Review protocol**

We did not prepare a formal review protocol for this study.
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Conflict of interest

Author 3 has a relationship with Zimmer Biomet, including consulting and research funding. Author 4 has a relationship with Stryker New Zealand and Smith + Nephew, including consulting and research funding. The funding bodies were not involved at any stage with study design, analysis or manuscript preparation. Authors 1 and 2 have no competing interests to declare.

Data availability statement

All data relevant to the study are included in the article or uploaded as online supplemental information.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jisakos.2020.06.001.

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