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Bearing design influences short- to mid-term survivorship, but not functional outcomes following lateral unicompartmental knee arthroplasty: a systematic review

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Abstract

Purpose To determine survivorship and functional outcomes of fixed and mobile-bearing designs in lateral unicompartmental knee arthroplasties (UKA).

Methods Medline, EMBASE and Cochrane databases were searched. Annual revision rate and functional outcomes were assessed for both fixed and mobile-bearing designs.

Results A total of 28 studies, of which 19 fixed-bearing and 9 mobile-bearing, representing 2265 lateral UKAs were included for survivorship and functional outcome analyses. The mean follow-up of fixed and mobile-bearing studies was 7.5 and 3.9 years, respectively. Annual revision rate of fixed-bearing designs was 0.94 (95% CI 0.66–1.33) compared to 2.16 (95% CI 1.54–3.04) for mobile-bearing. A subgroup analysis of the domed shaped mobile-bearing design noted an annual revision rate of 1.81 (95% CI 0.98–3.34). Good-to-excellent functional outcomes were observed following fixed and mobile-bearing lateral UKAs; no significant differences were found.

Conclusion Mobile-bearing lateral UKAs have a higher rate of revision compared to fixed-bearing lateral UKAs with regard to short- to mid-term survivorship; however, the clinical outcomes are similar. Despite the introduction of the domed shaped mobile-bearing design, findings of this study suggest fixed-bearing implant design is preferable in the setting of isolated lateral osteoarthritis (OA). This systematic review was based on low to moderate evidence, therefore, future registry data are needed to confirm these findings. However, this study included a large number of patients, and could provide information regarding risk of revision and functional outcomes of mobile and fixed-bearing type lateral UKA.

Level of evidence IV.

Keywords Lateral unicompartmental knee arthroplasty · Bearing design · Annual revision rate · Lateral UKA

Abbreviations

UKA	Unicompartmental knee arthroplasty
ROM	Range of motion
PROMs	Patient-reported outcome measures
BMI	Body mass index
OA	Osteoarthritis
TKA	Total knee arthroplasty
MINORS	Methodological index for non-randomized studies
CI	Confidence interval
SD	Standard deviations
KSS	Knee Society Score
OKS	Oxford Knee Scores

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Introduction

Unicompartmental knee arthroplasty (UKA) comprises 8–10% of all knee arthroplasties according to national registries [1–4]. Registries and cohort studies demonstrated lower survivorship of UKA compared to total knee arthroplasty (TKA) [5]. However, studies showed several advantages of UKA over TKA; lower infection and mortality rates, faster recovery, larger range of motion (ROM) and better patient-reported outcome measures (PROMs) [6–9]. Due to these advantages, as well as improvements in implant design and surgical techniques, and a better understanding of patient indications, UKA is gaining popularity [2–4]. The majority of all UKA procedures (85–95%) concern the medial compartment, while the surgical volume of the lateral UKA is limited [2, 4, 10]. Lateral UKA is performed less frequently as it is considered a more technically demanding surgical procedure and the prevalence of isolated lateral Osteoarthritis (OA) is lower compared to medial OA [11, 12].

The lateral tibiofemoral compartment has different anatomy and kinematics compared to the medial compartment, resulting in a greater anteroposterior translation during knee flexion. Furthermore, increased laxity in flexion is noted laterally [13–15]. Therefore, it has been suggested that implant design affects outcomes of lateral UKA to a greater extent than it may in medial UKA [16]. Currently, there are two bearing types available for UKA, mobile and fixed-bearing designs. Mobile-bearing designs have the theoretical advantage in restoring the biomechanics of the lateral compartment by allowing anteroposterior translation of the insert, which results in lower contact stresses on the polyethylene [14, 17]. However, due to the increased laxity, bearing dislocation has been reported frequently following lateral UKA surgery with mobile-bearing implants [16]. Therefore, in the setting of lateral UKA, the choice of bearing design remains controversial.

To our knowledge, limited evidence is available comparing outcomes of fixed and mobile-bearing lateral UKAs. Therefore, the primary aim of this study was to systematically assess survivorship of fixed and mobile-bearing lateral UKAs. Secondary, functional outcomes of both implant designs were evaluated. The hypothesis of this study was that fixed-bearing designs would show higher survivorship compared to mobile-bearing designs. Furthermore, it was expected that better functional outcomes would be reported following mobile-bearing lateral UKA.

Materials and methods

Search strategy

This systematic review was conducted according to PRISMA guidelines [18]. A comprehensive search was performed in Medline, EMBASE and Cochrane Library on February 12, 2018. Search terms included “unicompartmental”, “knee”, “arthroplasty” and the associated synonyms (“Appendix”). Additionally, common medical abbreviations and “lateral” were added. No limits on publication date or patient age were used. Search strategies are shown in “Appendix”. After removing duplicates, title and abstract of the studies were screened by two authors independently (JAB and LJK), considering the eligibility criteria (Table 1). References of included studies were checked for any missing studies. The third author (INS) was consulted in case of disagreement. Consensus was achieved with regard to inclusion or exclusion for all reviewed articles.

Data extraction

Data was extracted and collected in Microsoft Excel 2017 by one of the authors (JAB), and subsequently, checked for accuracy by another author (INS). The data from the included studies was divided into two groups based on bearing type: (1) fixed-bearing and (2) mobile-bearing lateral UKA. The first author, study design (retro- or prospective), study characteristics (publication year, country, time of inclusion, number of patients and knees), patient characteristics (age, sex, body mass index; BMI), arthroplasty (implant design, surgical approach, indication), implant survival

Table 1 Inclusion and exclusion criteria

Inclusion	
1	Main indication for surgery was isolated lateral osteoarthritis (> 90% of study cohort)
2	Intervention: lateral unicompartmental knee arthroplasty (UKA)
3	Reported bearing type: fixed or mobile-bearing
4	Sample size of minimal 15 patients (per bearing type)
5	Articles reporting implant survival data and/or pre- and postoperative clinical outcomes (e.g., range of motion, patient-reported outcome measures)
6	Retrospective or prospective study design
7	Articles written in English, Dutch or German languages
Exclusion	
1	Case reports, systematic reviews, in vitro studies and registry-based studies
2	Double publication of the same cohort
3	Previous implants in the index knee (e.g., medial unicompartmental knee arthroplasty, patellofemoral implant)
4	Studies not distinguishing between mobile and fixed-bearing type

data (revision, failure mode, follow-up) and functional outcomes (e.g., ROM, PROMs) were extracted. Authors were contacted for additional information when indication of the lateral UKA were unspecified. Results reported as medians were transformed to means by the method of Hozo et al. [19].

Implant survival data was transformed into annual revision rate to correct for different follow-up intervals between populations. This metric is defined as revision rate per observed component-year [5, 6]. Revision was defined as 'a new operation in a previously resurfaced knee during which one or more of the components are exchanged, removed, or added' according to the Swedish arthroplasty registry [4]. Therefore, additional medial UKA and patellofemoral arthroplasty for OA progression were both considered as a revision. Moreover, re-operations that were not clearly described were considered a revision.

Methodological quality assessment

Methodological quality assessment was performed independently by two authors (JAB and LJK) using the validated MINORS criteria (methodological index for non-randomized studies) [20]. The third author (INS) was consulted in case of disagreement.

Statistical analysis

Poisson-normal models with random effects were used to estimate pooled annual revision rate data separately for fixed and mobile-bearing lateral UKA cohorts. The log incidence rates of each cohort enabled the calculation of overall log incidence rates per bearing type. Pooled annual revision rates with 95% confidence intervals (CI) were obtained by back-transforming the log incidence rates. Analyses were conducted using R version 3.2.3 (R Foundation for Statistical Computing, Vienna, Austria) with Metafor version 1.9-8 (Maastricht University, Maastricht, Netherlands). In addition, a subgroup analysis was performed to determine the annual revision rate for the Oxford domed mobile-bearing design (Biomet UK ltd, Swindon, UK).

Primary lateral OA was the main indication in the majority of studies (> 75% of the cohort), however, in a proportion of the studies this information was lacking. A sensitivity analysis was conducted, as secondary OA could influence the result as it is associated with inferior outcomes [21, 22].

For pre- and postoperative functional outcomes, means and standard deviations (SD) for each bearing type were combined and reported as mean difference with 95% CI. These pooled analyses were performed with RevMan version 5.3 (Cochrane Reviews, London, UK) using the inverse variance method. If outcomes were reported with a range, the SD was calculated using the method by Walter and Yao [23]. A p value < 0.05 was considered to be statistically significant.

The heterogeneity between studies were determined by the χ^2 and I^2 statistic method in both the annual revision rate and functional outcome analyses. Heterogeneity was considered with a I^2 value of 25% to be low; 50%, moderate; and 75%, high [5].

Results

A total of 28 studies were included, representing 2265 lateral UKAs (Fig. 1) in 19 fixed-bearing and nine mobile-bearing studies [11, 16, 17, 22, 24–47]. Seventy-eight percent of the mobile-bearing studies used the Oxford domed design, while a variety of fixed-bearing implants were used. Nineteen (70%) studies used a lateral parapatellar approach, and eight (30%) used another approach (e.g., medial parapatellar, traditional TKA) or included multiple approaches over the course of the study. There was female predominance (range 52–93%). Mean age ranged from 53 to 74 years and mean BMI from 25 to 33 kg/m^2 (Table 2).

Quality of the studies

Twenty (71%) retrospective and eight (29%) prospective studies were included. The mean MINORS score of the comparative studies was 16.1 (range 13–18), and 9.4 (range 7–12) for the non-comparative studies, representing 67% and 59% of the maximum score, respectively (Table 2). None of the studies were blinded and only three (11%) reported prospective calculation of the sample size.

Annual revision rates

The overall annual revision rate of the fixed-bearing group was 0.94 (95% CI 0.66–1.33) and 2.16 (95% CI 1.54–3.04) for the mobile-bearing group (Table 3; Figs. 2, 3). A subgroup analysis was performed for the domed mobile-bearing design; showing an overall annual revision rate of 1.81 (Table 3; Fig. 4). Annual revision rates of each study were converted to survival rates and plotted (Fig. 5). Overall, heterogeneity was low among the fixed-bearing studies and moderate for mobile-bearing studies (Table 3). The sensitivity analysis for studies with unspecified indications for lateral UKA showed no differences in survival compared to studies that did specify their indication. The distribution of modes of failure is shown in Table 4. A total of seven fixed-bearing and five mobile-bearing studies specified the type of revisions performed [17, 24–26, 29, 31, 32, 35, 37, 38, 41, 42, 46]. It was noted that fixed-bearing lateral UKAs were more frequently converted to TKA (67.4% of mobile-bearing versus 41.9% of mobile-bearing), while tibial bearing or

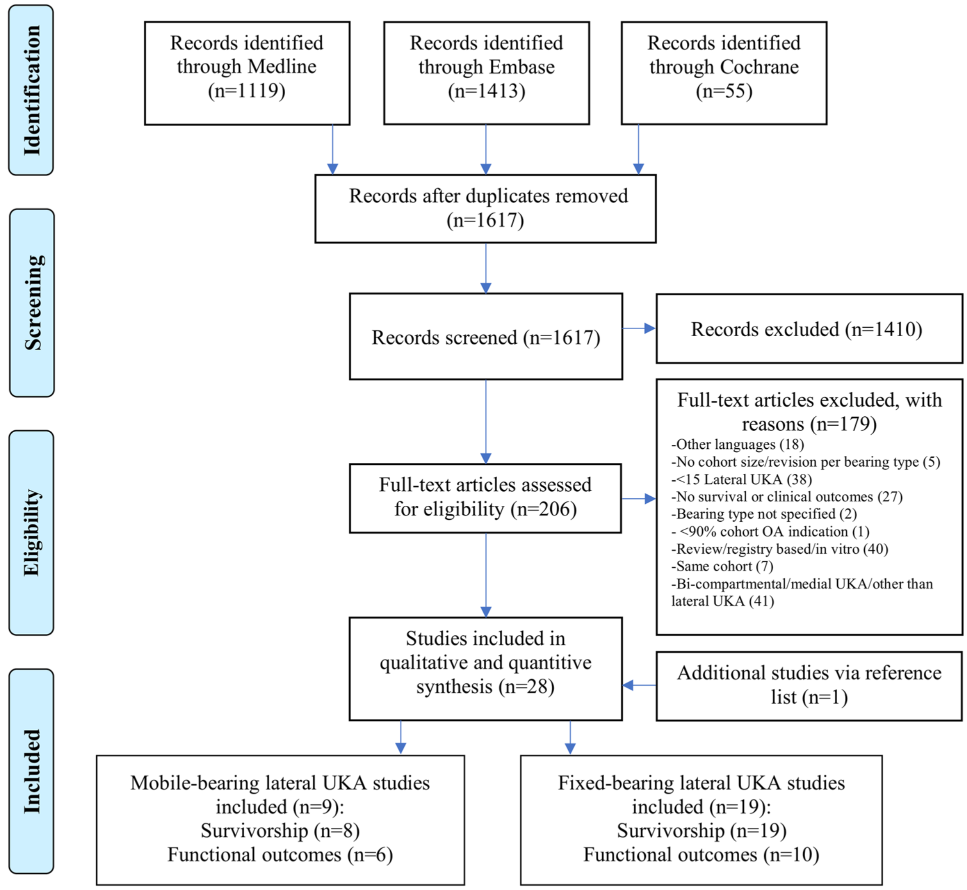

Fig. 1 Preferred reporting items for systematic reviews and meta-analyses flow diagram. *UKA* unicompartmental knee arthroplasty, *OA* osteoarthritis

insert exchange was more commonly reported after mobile-bearing lateral UKA (29% of mobile-bearing versus 0% of fixed-bearing).

Functional outcomes

A total of 11 studies reported pre- and postoperative PROMs and 13 studies reported ROM [11, 16, 17, 24, 26–29, 32, 35, 37, 38, 40, 42, 43, 45]. Overall, no statistically significant differences were found in KSS (Knee Society Score) knee, KSS function, KSS total, OKS (Oxford Knee Scores), nor in ROM between the two designs. Overall, heterogeneity was high among the fixed-bearing studies and high to low for mobile-bearing studies (Table 5).

Discussion

The main finding of this study was that the risk of revision is lower after lateral UKA with fixed-bearing designs than mobile-bearing designs. The annual revision rate of the mobile-bearing was 2.16, domed mobile-bearing 1.81 and fixed-bearing designs 0.94, corresponding to extrapolated 5-year survival rates of 89%, 91% and 95%, respectively. This dissimilarity between the two bearing types could be a consequence of a higher proportion of dislocations after mobile-bearing lateral UKAs (44%) compared to fixed-bearing lateral UKAs, although the new domed mobile-bearing design reduces the number of bearing dislocations. Progression of OA in the medial compartment was observed as mode of failure in both fixed-bearing and mobile-bearing designs (53% and 19%, respectively). Furthermore, good-to-excellent PROMs and ROM were noted with both bearing types, which did not support our hypothesis favoring the use of mobile-bearing designs based on functional outcome. This study highlights the importance of assessing survivorship and functional outcomes in lateral UKAs per bearing type using a systematic approach, due to the low prevalence of this procedure.

Currently, studies comparing fixed and mobile-bearing lateral UKA survivorship are limited. One large registry-based study by Baker et al., including 2052 lateral UKAs, found no statistical difference in survival between fixed and mobile-bearing designs [10]. Contrary to our definition for revision, the authors did not differentiate between individual components for each prosthesis, which could lead to smaller differences in survival rates between the two bearing types. Therefore, it is important to bear in mind that the definition

Table 2 Study characteristics

Study	Year	Country	Cohort	Implant design[a]	Surgical approach	BMI	Female (%)	Mean age (years) (SD or range)	Knees at baseline (n)[b]	Failed (n)	Mean FU (years) (SD or range)	MINORS score	Study design
Mobile-bearing													
Liebs	2013	Germany	2002–2009	Pres	L	N/A	N/A	73.6 (44–91)[c]	128	13	6 (2.1–9.8)[c]	10/16	Retr
Newman	2017	UK	2005–2009	Oxf domed	L	N/A	71	71 (44–92)	64	7	6.72 (2–9.92)	10/16	Pros
Pandit	2010	UK	1983–1991	Oxf ph I&II	TKA	N/A	92	68 (40–88)	53	11	11	15/24	Retr
			1998–2004	Oxf ph III	L	N/A	56	53 (39–83)	65	9	9		
			2004–2008	Oxf domed	L	N/A	61	62 (41–86)	101	1	1		
Saxler	2004	Germany	1991–2000	AMC uniglide	TKA, L, M	N/A	67[c]	69.5 (46–89)[c]	46	5	5.5 (2.3–12.5)[c]	7/16	Retr
Schelfaut	2013	Belgium	2009–2011	Oxf domed	L	26.3	64	60 (31–86)	29	2	1.67 (1–2.83)	11/16	Pros
Weston-Simons	2014	UK	2004–2012	Oxf domed	L	N/A	N/A	64 (32–90)	265	12	4.1 (0.5–8.3)	12/16	Pros
Van Duren	2014	UK	N/A	Oxf domed	L incl. trans	N/A	66	65.6 (41.7–84.3)	50	0	2.28 (0.53–6.01)	16/24	Retr
			N/A	Oxf ph III	L	N/A	53	57.3 (39.7–80.0)	30	0	1.03 (0.63–2.23)		
Walker	2018	Germany	2006–2014	Oxf domed	L	N/A	72	65 (36–88)	344	36	3.08 (1–7.75)	9/16	Retr
Walker	2015	Germany	N/A	Oxf domed	L	N/A	58	60.1 (36–81)	45	0	2.95 (2–4.25)	8/16	Retr
Fixed-bearing													
Argenson	2008	France	1982–2004	M-like, Alpina, MG, ZUK	L, M	26	62	61 (34–79)	40	5	12.6 (3–23)	10/16	Retr
Ashraf	2002	UK	1978–1999	St GS/modified	L, M	N/A	86	69 (35–81)	83	15	9 (2–21)	10/16	Pros
Berend	2012	USA	2004–2008	Repicci II, Vang MTM	L	30	70	68 (14)	132	1	3.25 (2–6.75)	9/16	Retr
Dejour	1998	France	1989–1991	HLS uni evolution	L, TO	N/A	85	71 (51–86)	27	0	1.5 (1–2.25)	10/16	Retr
Demange	2015	USA	2007–2009	iUni G1	L	28.7	66	59 (44–88)	33	2	3.08 (2–4.42)	16/24	Retr
			2003–2009	MG	L	32.7	53	56 (37–71)	20	3	6.25 (2.17–9.08)		
Edmiston	2017	USA	2003–2014	MG	L, M	28.2	66	61.3 (11.2)	65	4	6.86 (3.07)	17/24	Retr
Forster	2007	Australia	2001–2003	Pres	L	N/A	69	75 (55–93)	17	0	2 (2–3)	18/24	Pros
Heyse	2012	Germany	1993–2004	Accuris	L	N/A	56[c]	53.7 (30–60)[c]	50	3	10.8 (5–16)[c]	8/16	Retr
Kim	2016	Korea	2011–2014	ZUK	L	N/A	52	63.3 (48–80)	29	1	3.17 (2–4)	9/16	Retr
List	2016	USA	2008–2014	RESTORIS MCK	L	26.6	65	66.2 (12.1)	48	0	2.7 (2–5)	16/24	Retr
Lustig	2014	France	1998–2003	HLS Uni evolution	L, TO	25.08	84	72.2 (25–85)	46	7	14.2 (10.17–18)	10/16	Retr

Table 2 (continued)

Study	Year	Country	Cohort	Implant design[a]	Surgical approach	BMI	Female (%)	Mean age (years) (SD or range)	Knees at baseline (n)[b]	Failed (n)	Mean FU (years) (SD or range)	MINORS score	Study design
Marson	2014	UK	2007–2011	ZUK	L	N/A	N/A	57.9 (40–84)	15	0	2.72 (1–5.92)	13/24	Retr
Ohdera	2001	Japan	1977–1999	M, PCA, Omni	N/A	25.4	78	64.5 (52–77)	18	2	8.25 (5–15.75)	6/16	Retr
Pennington	2006	USA	1988–2001	MG	L	28	88	68 (52–86)	29	0	12.4 (3.1–15.6)	8/16	Retr
Romagnoli	2013	Italy	1991–2010	N/A	L	26.5	82	67 (40–89)	184	11	13.2 (2–20)	9/16	Pros
Sah	2007	USA	1991–2004	Brigh, PFC/sigma, Pres	M	25	80	61 (37–84)	48	0	5.2 (2–15)	18/24	Retr
Smith	2014	USA	2002–2011	AMC uniglide	L	N/A	68	64.8 (36–91)	101	4	3.9	11/16	Pros
Volpi	2007	Italy	2000–2005	MG	L	N/A	93	73.5 (65–82)	28	0	2.35 (1–5)	10/16	Pros
Xing	2012	USA	2004–2007	Pres	L	28.8[c]	N/A	67 (36–90)[c]	31	0	4.5 (2–6.42)[c]	11/16	Retr

FU follow-up, *L* lateral parapatellar, *M* medial parapartellar, *TKA* traditional total knee arthroplasty, *TO* tibial tubercle osteotomy, *trans* trans-patella tendon, *Med* median, *MINORS* methodologic index for non-randomized studies, *N/A* not available

[a] *Pres* the preservation, fixed or mobile (DePuy International Ltd, Leeds, UK), *Oxf ph* Oxford phase I, II, III or domed (Biomet UK Ltd, Swindon, United Kingdom), *AMC uniglide* mobile or fixed (Corin, Cirencester, UK), *M or M-like* Marmor or Marmor-like (Zimmer, Warsaw, IN-USA), Alpina (Biomet, Bridgend, UK), *MG* Miller Galante (Zimmer, Warsaw, IN-USA), ZUK high flex (Zimmer,Warsaw, IN-USA), *St. GS* St. George Sledge, also modified (Waldermar Link, Hamburg, Germany), *Repicci II* (Biomet, Warsaw, IN-USA), *Vanguard M* (Biomet, Warsaw, US), HLS uni evolution (Tornier, st. Ismier, France), iUni G1 (Conformis, Burlington, MA-USA), Accuris system (Smith & Nephew, Memphis, TN-USA); ReSTORIS MCK (MAKO Surgical Corp, Ft. Lauderdale, FL, USA), *PFC* Press Fit Condylar, also Sigma (DePuy, Johnson & Johnson, Warsaw, IN-USA), *Brigh* Brigham unicondylar (DePuy, Johnson & Johnson, Warsaw, IN-USA), *Omni* Omnifit B (Stryker, Kalamazoo, MI), *PCA* Porous-coated anatomic uni (Howmedica, Rutherford, NJ)

[b] Number of knees at baseline can be different from knees included in survival analyses and functional outcome analyses

[c] Study characteristic was not reported for subgroup

Table 3 Annual revision rate per bearing type or design

Bearing type/design	Studies (*n*)	Mean age (years)*	Knees (*n*)	Revisions (*n*)	Mean FU (years) (range)[a]	OCY	Survivorship	
							ARR (95% CI)	Heterogeneity I^2 (%)
Fixed	19	65.4	1011	58	7.5 (1.5–14.2)	7589	0.94 (0.66–1.33)	32
Mobile	8	65.2	1171	96	3.9 (1.8–6.7)	4424	2.16 (1.54–3.04)	54
Domed	6	64.7	849	58	3.5 (1.7–6.7)	2934	1.81 (0.98–3.34)	67

FU follow-up, *OCY* observed component years, *ARR* annual revision rate, *CI* confidence interval

[a]Weighted means by study size

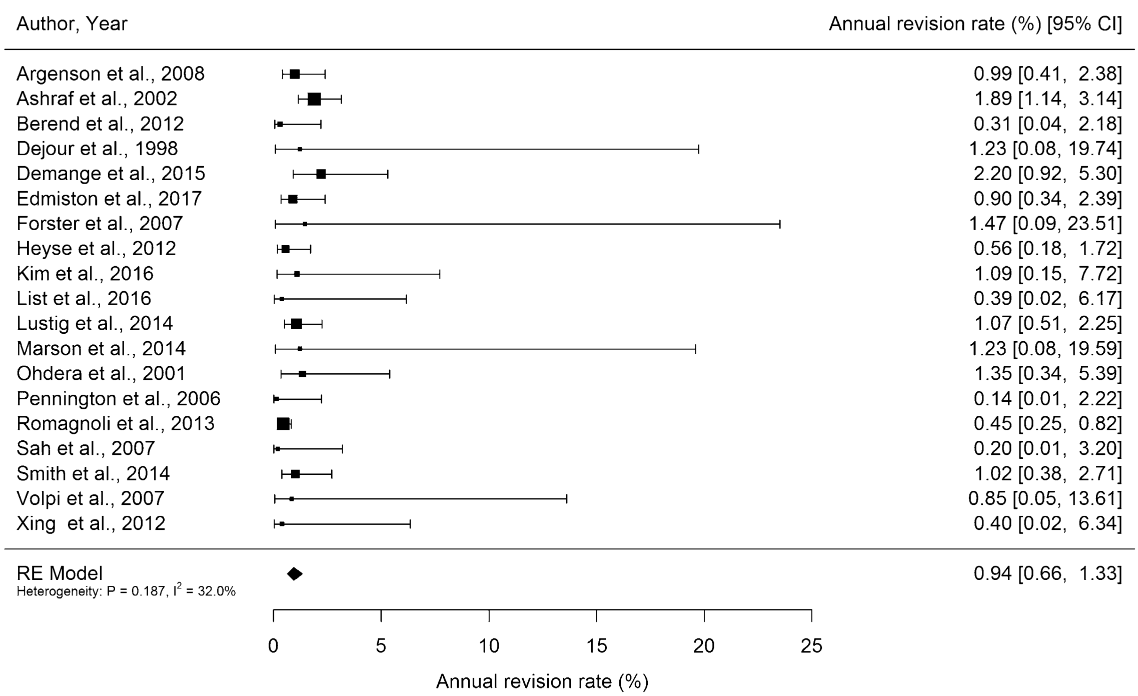

Fig. 2 Annual revision rates of fixed-bearing studies. *CI* confidence interval

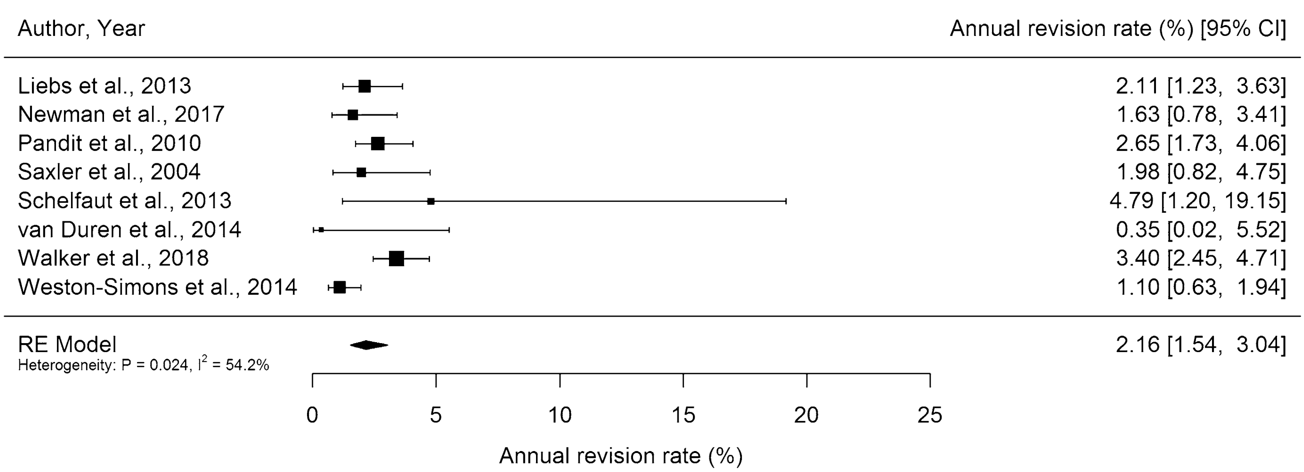

Fig. 3 Annual revision rates of mobile-bearing studies. *CI* confidence interval

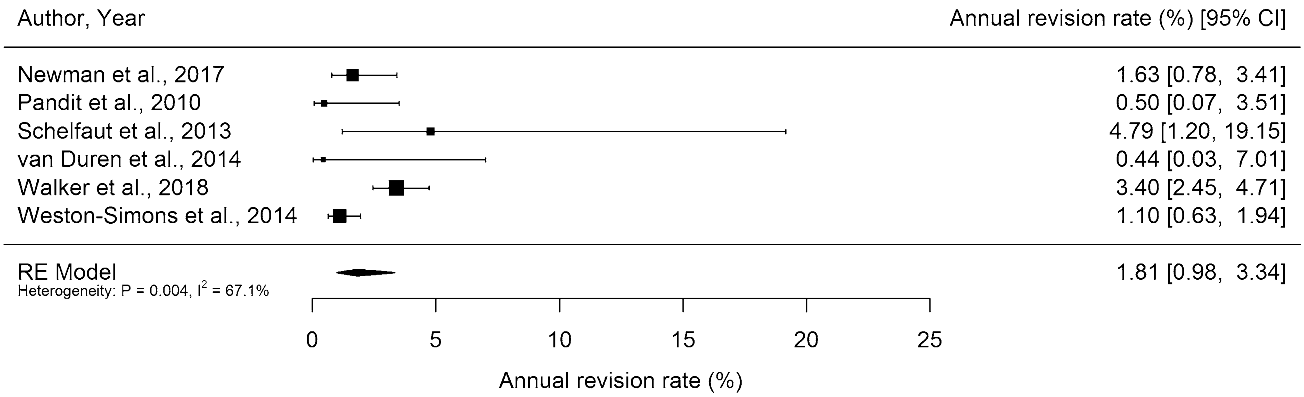

Fig. 4 Annual revision rates of domed mobile-bearing cohorts. *CI* confidence interval

Fig. 5 Survival rates with length of follow-up from all included studies per bearing type. Diameter of circle representing cohort size

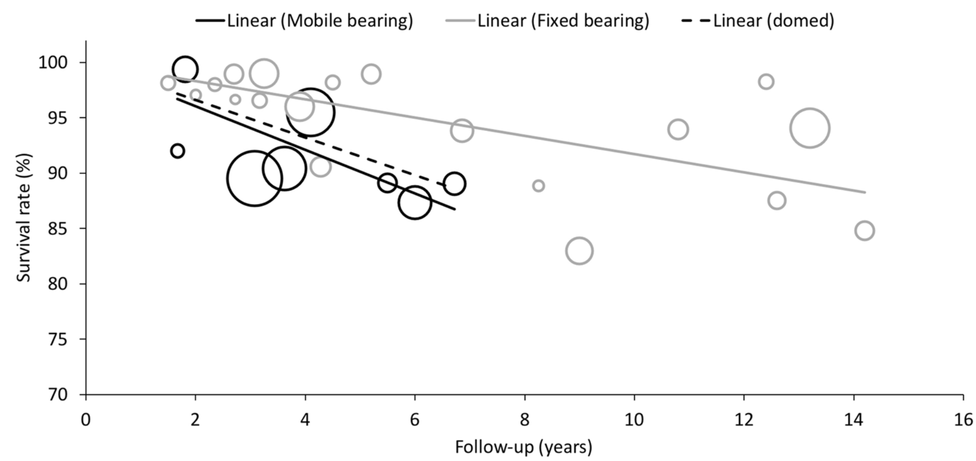

Table 4 Failure mode per bearing type or design

Bearing type or design	Fixed-bearing	Mobile-bearing	Domed
Number of lateral UKA revisions	58	96	58
Progression OA medial compartment, *n* (%)	31 (53)	18 (19)	12 (21)
Bearing dislocation, *n* (%)	0	42 (44)	30 (52)
Aseptic loosening, *n* (%)	3 (5)	8 (8)	1 (2)
Pain, *n* (%)	3 (5)	5 (5)	5 (9)
Infection, *n* (%)	3 (5)	9 (9)	5 (9)
Periprosthetic fracture, *n* (%)	2 (3)	3 (3)	0 (0)
Instability, *n* (%)	3 (5)	5 (5)	5 (9)
Polyethylene wear, *n* (%)	2 (3)	0	0
Tibial subsidence, *n* (%)	1 (2)	0	0
Femoral component fracture, *n* (%)	4 (7)	0	0
Others, *n* (%)[a]	6 (10)	6 (6)	0

Mean follow-up of fixed-bearing, mobile-bearing and domed mobile-bearing studies were 7.5, 3.9 and 3.5 years, respectively

UKA unicompartmental knee arthroplasty, *OA* osteoarthritis, *Domed* Oxford domed mobile-bearing

[a]Includes ligament injury, recurrent heamarthrosis, pigmented villonodular synovitis, internal fixation, impingement post-traumatic wound dehiscence, impression of patella by lateral tibial component and unknown causes

Table 5 Effect of lateral unicompartmental knee arthroplasty on different functional outcomes

	Bearing type	Studies (*n*)	Knees (*n*)	Baseline mean (SD)[a]	Effect		
					Change from baseline (95% CI)	Heterogeneity I^2	*p* value
ROM	Mobile	3	222	115 (18)	8.38 (11.37–5.39)	0%	ns
	Fixed	10	469	117 (10)	6.38 (11.55–1.21)	97%	
KSS function	Mobile	4	386	64 (18)	21.38 (26.58–16.17)	71%	ns
	Fixed	4	207	52 (16)	27.11 (39.91–14.32)	98%	
KSS knee	Mobile	4	370	49 (17)	36.52 (44.49–28.55)	90%	ns
	Fixed	4	163	54 (15)	34.65 (42.21–27.10)	93%	
KSS total	Mobile	1	69	110 (34)	54.58 (66.63–42.53)	N/A	ns
	Fixed	2	94	116 (26)	40.26 (77.37–3.14)	95%	
OKS	Mobile	6	446	24 (8)	15.28 (16.72–13.84])	43%	ns
	Fixed	1	33	20 (10)	17.30 (21.89–12.71)	N/A	

ROM range of motion, *KSS* Knee Society Score, *OKS* Oxford Knee Score, *SD* standard deviation, *CI* confidence interval, *ns* not significant

[a]Weighted means and standard deviations by study size of pre-operative clinical outcomes

of revision could influence study results. Our extrapolated 5-year survival rate of domed mobile-bearing was higher when compared to a recent Danish registry, which included 52 domed mobile-bearing implants (91% versus 87.4%, respectively) [48]. To our knowledge, no other registry or systematic review has assessed lateral UKA survivorship per bearing type. In summary, this overview stresses the need for studies and registries to assess survivorship of lateral UKAs per bearing type, as data are very limited.

Regarding modes of failure, bearing dislocation was frequently noted in mobile-bearing designs (44%), whereas progression of OA in the medial compartment was common in both fixed and mobile-bearing designs (53% and 19%, respectively). Most of the included studies failed to report the time of revision with corresponding mode of failure. Therefore, in this study, modes of failure per bearing type could not be corrected by follow-up period. This may explain the higher percentage of progression of medial OA in the fixed-bearing group, as their average follow-up is longer and progression of OA often occurs later after the initial surgery. The high percentage of bearing dislocations in mobile-bearing lateral UKAs may be due to larger joint distraction in flexion laterally compared to medially (7 mm versus 2 mm) [15]. To lower the rates of bearing dislocation, the domed mobile-bearing tibial implant has been introduced. This implant potentially reduces the incidence, as it requires more distraction before the polyethylene insert dislocates, however, it does not eliminate the possibility of bearing dislocation [13, 16]. Overall, the available literature implicates that the benefit of using fixed-bearing designs is that bearing dislocation cannot occur.

When reviewing mobile-bearing results, surprisingly no dislocations were observed in two studies. Liebs et al. used a mobile-bearing of which the insert slides into a groove from anterior to posterior, while medial–lateral translation is restrained. Consequently, dislocation did not occur; however, aseptic loosening was frequently noted, and therefore, this implant is no longer used [30, 33, 49]. The study by Van Duren et al. used a trans-patellar approach to optimize the access for the vertical cut of the tibia [28]. This approach allows the surgeon to place the tibial component and bearing in a potentially more optimal position. No dislocations of the domed mobile-bearing were reported at a relatively short median follow-up of 27.4 months. Several studies suggested that component alignment is critical to reduce the risk of dislocation in mobile-bearing designs [50, 51]. Gulati et al. recommended after radiographic evaluation of knees with dislocated bearings that overstuffing should be avoided and the femoral component needs to be neutrally aligned in flexion.

Several mobile-bearing studies have managed bearing dislocation successfully by replacing the bearing with a thicker one. In addition, the revision method by Weston-Simons et al. was used, in which the bearing was exchanged and two to three screws were inserted with their heads above the medial wall of the tibial plateau to prevent recurrent dislocation [17]. According to the Australian registry, these types of revision are classified as a minor revision, but have a higher risk of re-revision compared to revision to TKA [2, 52]. Therefore, UKA surgeons need to carefully consider if bearing exchange is a useful option when revising a UKA on the lateral side for bearing dislocation.

To prevent progression of OA in the medial compartment following mobile and fixed-bearing lateral UKAs, it is generally stated that overcorrection should be avoided [24, 35, 38, 43]. Ohdera et al. suggested a valgus aligned mechanical axis between 5°–7° should be aimed in lateral UKA surgery [38]. Furthermore, Van der List et al. showed that postoperative valgus of 3°–7° was correlated with better functional outcomes than more neutral aligned knees [53].

However, a cautious approach is needed since MUKA studies reported that undercorrection is associated with polyethylene wear [54, 55]. Based on the results of this study and those reported by Baker et al., polyethylene wear was less frequently reported as a mode of failure after lateral UKA [10]. Future studies are necessary to evaluate the association between degree of valgus and polyethylene wear following lateral UKAs.

In the present study, no statistically significant differences were found in functional outcomes between both bearing types. Mobile-bearing UKAs may have theoretical biomechanical advantages; however, this did not affect the functional outcomes after surgery. Only two small comparative studies assessed functional outcomes, and similarly, showed no statistically significant differences in OKS and ROM between both designs [30, 36].

This study has several limitations. Although the metric annual revision rate corrects for different follow-up intervals between studies, it relies on the assumption that the revision rate remains constant over time. Therefore, mobile-bearing findings have to be interpreted with more caution than those for fixed-bearing, because annual revision rate of mobile-bearing were only based on short- to mid-term results. Furthermore, despite the majority of studies having > 70% patients with primary OA and having performed a sensitivity analysis based on indication, considerable variability of the indication for each procedure existed. Another limitation is that a majority of the studies consisted of small cohorts with low to moderate quality. In addition, several cohort studies in the domed mobile-bearing group have led to concerns about the reliability due to developer bias, therefore, assessing survivorship and functional outcomes with registry data may be helpful. However, only one annual registry reported survivorship of the domed mobile-bearing design and one registry-based study reported results of both bearing types separately. Hence, this study provides insights to the current literature.

Conclusion

In conclusion, mobile-bearing lateral UKA have a higher rate of revision compared to fixed-bearing lateral UKA with regard to short- to mid-term survivorship; however, the clinical outcomes are similar. Despite the improvements in mobile-bearing implants with a domed shaped design, short- to mid-term survivorship remains inferior to the fixed-bearing designs due to a high percentage of bearing dislocations leading to revision. Other common failure modes in both the fixed and mobile-bearing designs were progression of OA. As a result of the moderate evidence included in this study, future registry data are needed to confirm these findings. Nonetheless, the results of this study suggest a preference of using fixed-bearing implants for isolated lateral knee OA.

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Author contributions JB performed the literature search, scanned all abstracts and full texts of the included articles, determined the quality of the studies and wrote the manuscript. LK screened all abstracts, full texts and determined the quality of the studies as a second author; and helped to draft the manuscript. IS provided suggestions on the review process, statistical analyses and manuscript; and checked the data extraction. HG participated in the design of the study and revised the manuscript. PN coordinated this study, participated in its design and revised the manuscript. All authors read and approved the final manuscript.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interests.

Ethical approval No ethical approval was obtained because this study was a systematic review using de-identified data from other cohort studies.

Appendix

See Table 6.

Table 6 Search strategies: February 12, 2018

Database	Search term	Search result
Medline	(((((((((“prosthesis implantation”[MeSH Terms] OR (“prosthesis”[tiab]) OR “prosthesis”[tiab] OR “prostheses and implants”[MeSH Terms] OR “prostheses”[tiab]))) OR ((“replacement”[tiab] OR “replacements”[tiab] OR implant[tiab] OR “implants”[tiab]))) OR ((“arthroplasty”[MeSH Terms] OR “arthroplasty”[tiab] OR “arthroplasties”[tiab])))) AND ((“knee”[MeSH Terms] OR “knee”[tiab] OR “knee joint”[MeSH Terms] OR (“knee”[tiab] AND “joint”[tiab]) OR “knee joint”[tiab]))) AND ((unicompartmental[tiab] OR partial[tiab] OR unicondylar[tiab])))) OR ((UKA[tiab] OR UKR[tiab] OR UCA[tiab] OR UCR[tiab] OR PKA[tiab] OR PKR[tiab] OR PCA[tiab])) AND lateral[tiab]	1119
Embase	(((‘knee’/exp OR knee:ti,ab OR (knee:ti,ab AND joint:ti,ab) OR ‘knee joint’:ti,ab) AND (unicondylar:ti,ab OR unicompartmental:ti,ab OR partial:ti,ab) AND (‘arthroplasty’/exp OR (artroplasty:ti,ab OR arthroplasties:ti,ab) OR (replacement:ti,ab OR replacements:ti,ab OR implant:ti,ab OR implants:ti,ab) OR ‘orthopedic prosthesis’/exp OR (prosthesis:ti,ab OR prostheses:ti,ab))) OR (uka:ti,ab OR ukr:ti,ab OR uca:ti,ab OR ucr:ti,ab OR pka:ti,ab OR pkr:ti,ab OR pca:ti,ab)) AND lateral:ti,ab	1413
Cochrane	#1: MeSH descriptor: [Knee Joint] explode all trees #2: MeSH descriptor: [Knee] explode all trees #3: knee:ti,ab,kw #4: knee:ti,ab,kw and joint:ti,ab,kw #5: #1 or #2 or #3 or #4 #6: MeSH descriptor: [Arthroplasty] explode all trees #7: arthroplasty:ti,ab,kw or arthroplasties:ti,ab,kw #8: #6 or #7 #9: replacement:ti,ab,kw or replacements:ti,ab,kw or implant:ti,ab,kw or implants:ti,ab,kw #10: prosthesis:ti,ab,kw or protheses:ti,ab,kw #11: MeSH descriptor: [Prosthesis Implantation] explode all trees #12: MeSH descriptor: [Prostheses and Implants] explode all trees #13: #10 or #11 or #12 #14: unicompartmental:ti,ab,kw or partial:ti,ab,kw or unicondylar:ti,ab,kw #15: #8 or #9 or #13 #16: UKA:ti,ab,kw or UKR:ti,ab,kw or UCA:ti,ab,kw or UCR:ti,ab,kw or PKA:ti,ab,kw or PKR:ti,ab,kw or PCA:ti,ab,kw #17: #14 and #15 and #5 #18: #16 or #17 #19: lateral:ti,ab,kw	55
Total		1617

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